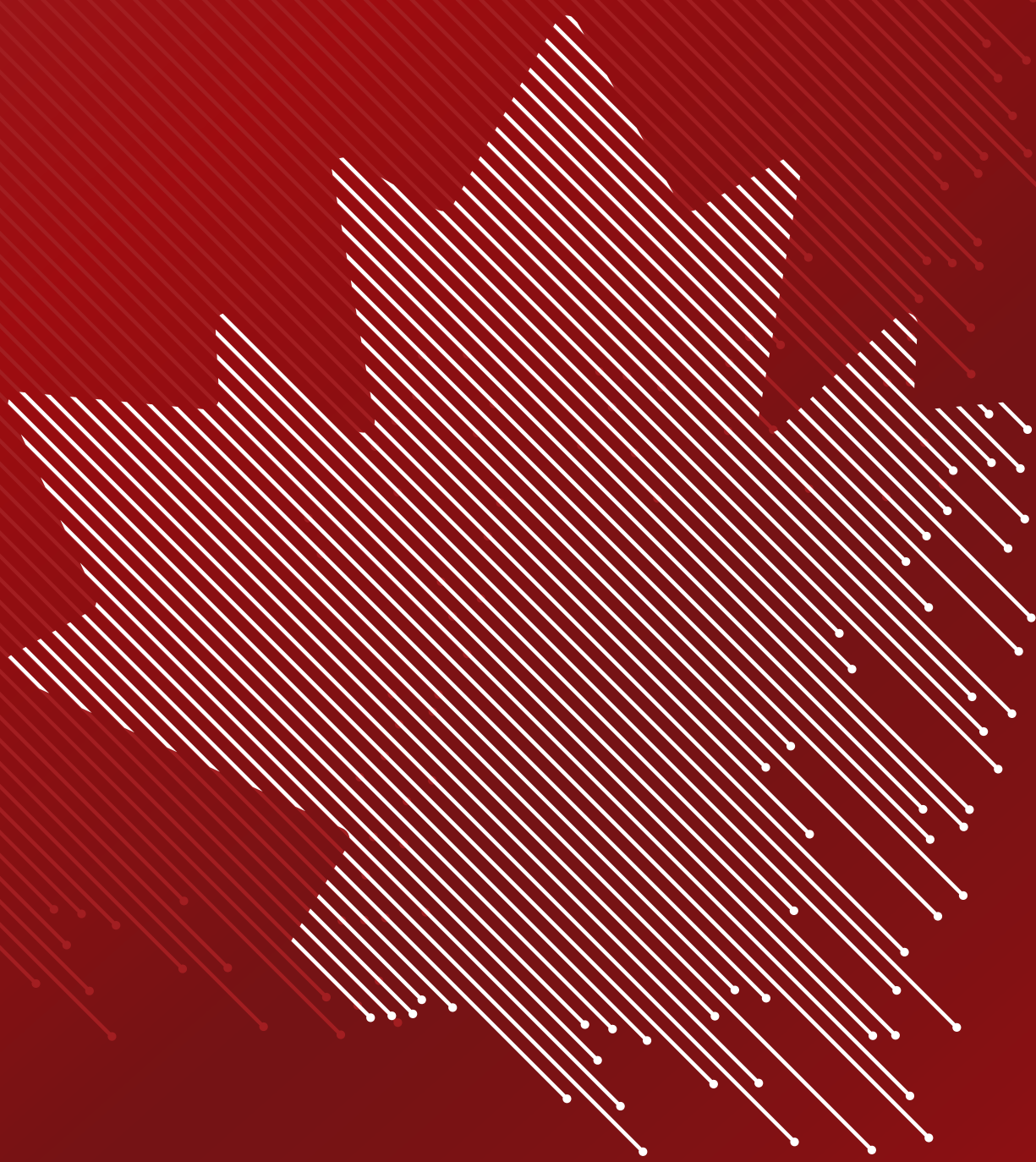


BETTING ON RED AND WHITE

International Investment in Canadian AI



JULY 2020



Research by



The Information and
Communications Technology Council

Funding provided
by Invest in Canada



PREFACE

ICTC is a national centre of expertise on the digital economy. With over 25 years of experience in research and program development 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.

To cite this report:

Cutean, A., Hamoni, R., Herron, C., Schuller, K. (July 2020). *Betting on Red and White: International Investment in Canadian AI*. Information and Communications Technology Council. Ottawa, Canada.

Researched and written by Alexandra Cutean (Senior Director, Research & Policy), Rosina Hamoni (Research Analyst), Chris Herron (Junior Research Analyst), and Kiera Schuller (Research & Policy Analyst), with generous support from the ICTC Research & Policy team.

ABSTRACT

This study examines opportunities for Canada to utilize current strengths in Artificial Intelligence (AI) to attract high-quality foreign direct investment (FDI). To lay the necessary groundwork, this research provides an overview of recent AI activities and developments, both in Canada and other global AI hubs, including the United States and Europe. It highlights examples of AI applications across sectors such as digital technology, agriculture, life sciences and others. Through in-depth analysis of key informant interviews (KIIs) with industry leaders from over eight countries and seven sector verticals, this study unravels core business needs filled by AI, international knowledge of Canadian advancements in the space, and perceptions of Canada as a destination for AI-based investment. Combined, this study sheds light on how potential investors from around the world view Canada's presence in AI research, commercialization, as well as the opportunities and barriers to continued growth. This study includes an analysis of overall strengths, weaknesses, opportunities and threats (SWOT) in relation to Canada's AI-based FDI-attraction strategy. Building on existing ICTC research on AI and its applications, this research suggests that Canada is viewed as an attractive destination for AI investment by some of the world's top business leaders. Key attributes tied to this perception are a highly skilled talent base, strong educational institutions with innovative programming, and a friendly immigration climate that attracts skilled mid- and senior-level AI talent needed to fill critical roles.

This research was conducted using questions that sought to extract insights on AI applications, Canada's AI ecosystem, and investment considerations. It does not directly take into consideration the recent COVID-19 pandemic, which has undoubtedly shifted global priorities, needs, and investment potential. Further detailed research is required to more fully understand the impacts of COVID-19 on AI developments and investment.

GLOSSARY OF TERMS

Accelerator A short, intense “business-building” program in which selected startups—often technology based—are given help to scale, troubleshoot problems and reach profitability as soon as possible. Often in exchange for a share of company equity, startups that go through accelerator programs receive small investments and access to a wide membership network including venture capitalists and industry experts. These tools are intended to enable market-ready companies to scale and commercialize. Admission into these programs is extremely competitive; globally, the most prestigious accelerators come with an acceptance rate of 1-2%.¹

Artificial Intelligence (AI) A multi-disciplinary subject, involving methodologies and techniques from various fundamental disciplines such as mathematics, engineering, natural science, computer science, and linguistics, to name a few. Over the last few decades, AI has evolved into a number of technological areas such as planning, natural language processing, speech processing, machine learning, vision recognition, neural networks and robotics, among others.²

Machine Learning Machine learning (ML), a subset of the broader field of AI, is the application of algorithms that provide systems with the ability to automatically learn and improve from past experiences without being explicitly programmed. ML algorithms are built on mathematical models that are based on sample of “training data” in order to make predictions or decisions.

Neural Networks Neural networks are computing systems made of numerous simple, interconnected processing elements that respond to external inputs.

Deep Learning an AI field closely associated with artificial neural networks. Deep Learning refers to the depth of multiple layers or stacks of neural networks.

Natural Language Processing (NLP) Technology used to aid computers in understanding human natural language. Most NLP techniques utilize machine learning in the process.

Tech Cluster (aka tech ‘Hub’) Often referred to as innovation or industry clusters,³ a tech cluster or hub is a concentration—usually geographic—of independent companies, educational institutions and relevant government institutions working together to for the benefit of a particular aim (e.g. to advance a certain sector or field). Companies in these clusters or hubs benefit from networking and knowledge-transfer opportunities, as well as access to skilled talent from the educational institutions within them. Examples include Silicon Valley’s technology cluster or Boston’s biopharma cluster. Clusters with many companies within them (typically hundreds or more) can be referred to as superclusters.

¹ Paula Karpis, “Want to Get Into a Top Startup Accelerator? Try These 3 Strategies”, *Forbes*, May 30, 2017, <https://www.forbes.com/sites/paulinaguditch/2017/05/30/get-into-a-top-startup-accelerator/#717a0f725f57>

² Ryan McLaughlin et al., “On the Edge of Tomorrow: Canada’s AI Augmented Workforce”, ICTC, December 2019, <https://www.ictc-ctic.ca/wp-content/uploads/2020/02/canadas-ai-workforce-FINAL-ENG-2.24.20.pdf>.

³ “Building successful technology clusters”, RAIN Eugene, December 10, 2014, <http://www.raineugene.org/building-successful-technology-clusters/>.

Digital Economy A classification that includes both workers employed in largely digital or technical roles across all sectors of the economy (e.g. the data scientist working for an airline), and workers employed in non-technical roles within technology companies (e.g. the accountant working at a software company).

Foreign Direct Investment (FDI) A category of cross-border investment in which an investor resident in one economy establishes a lasting interest in, or a significant degree of influence over, an enterprise resident in another economy.

Incubator An organization offering startups—usually technology-based, though not always—a suite of services including workspace, mentorship services, and connections to the local business community. Incubators may be sponsored by venture capital firms, angel investors, government, and even corporations. While in the incubator, startups usually work closely with other companies in a similar sector and spend significant amounts of time defining their product and business model. Accelerators focus on helping businesses reach profitability; incubators focus on earlier-stage companies, helping them build out business plans, create market-ready products and refine their intellectual property (IP).

TABLE OF CONTENTS

Preface	3
Glossary of Terms	5
Executive Summary	9
Introduction	11
Section I: The Global State of AI: Developments in Canada and Abroad	13
<i>The State of AI in Canada</i>	13
Edmonton	14
Montreal	15
Toronto	16
<i>A New Reality: Key AI Developments in Canada during COVID-19</i>	17
<i>The State of AI Around the World</i>	19
AI Developments in the US	19
AI Developments in the China	21
AI Developments in the European Union	23
Section II: Global Perceptions of Canada in the AI Space	26
<i>Engaging With Experts: Discussions With Industry Leaders</i>	26
<i>Organizations Use Different Types of AI to Respond to Five Key Business Needs</i>	27
Product Enhancement	28
Generating Efficiency and Improving Internal Processes	29
Improving Customer Experience	30
Expanding and Diversifying Consulting Services	31
Risk Management and Analysis	32
<i>Most Organizations are New to AI Investment, But All are Optimistic About its Potential</i>	33
<i>Organizations Mostly Face Minor Barriers to AI Implementation</i>	34
<i>Most Respondents had Knowledge of Canada in the AI space. Many were Familiar with Key AI Hubs, Canadian cities, the Scale AI Initiative, and Top Educational Institutions</i>	35
<i>Canada Recognized for its Growing AI Community, Proactive Immigration System and Ability to Attract Skilled Mid- and Senior-Level Internationally Trained Professionals</i>	37
<i>Main Barriers for AI Investment Attraction in Canada were Unclear Regulation, Competition for Talent, and the Small Size of the Canadian AI Ecosystem</i>	38

Section III: The Impact of AI Across Sectors	40
<i>Advanced Manufacturing</i>	40
<i>Agriculture and Ocean Technology</i>	42
<i>Business and Finance</i>	44
<i>Digital Technology</i>	45
<i>Life Sciences</i>	46
<i>Natural Resources</i>	48
<i>Transportation and Logistics</i>	49
Section IV: Rollup: Is AI a Vehicle for Attracting FDI into Canada?	51
<i>Skilled Canadian AI Talent a Key Pull Factor</i>	51
<i>Capacity to Attract Skilled International Talent is Compelling</i>	51
<i>Regional Hub Development</i>	52
<i>Leadership on Ethical AI</i>	52
<i>Scale Up Issues Exist—Canada Has Good Research, but Commercialization Needs a Boost</i>	52
<i>Talent Retention Worries</i>	53
<i>Slow Movement in Regulation a Challenge</i>	53
Conclusion	54
Appendices	55
<i>Research Methodology</i>	55
Primary Research	55
Secondary Research	55
<i>Limitations of Research</i>	56
<i>SWOT Analysis: A Profile of Canada for AI Investment</i>	56
Strengths	56
Weaknesses	58
Opportunities	61
Threats	63

EXECUTIVE SUMMARY

With subsets like machine learning, natural language processing, deep learning and more, AI can transform how our economies and societies function. Businesses worldwide are coming to rely on AI to generate efficiencies, increase productivity, and solve problems. AI can improve internal processes, enhance customer experience, manage risks, and can even create new products or services altogether.

Many organizations now use some form of AI, but to better understand where Canada stands as a destination for international AI-based investment, ICTC consulted with industry experts from eight countries to frame this picture. Interviewees represented global businesses whose main activities were found across seven industry areas.

Although their years of experience in using AI varied, the assertion of its value was unanimous; all interviewees were optimistic and about its potential to enhance businesses, both in the short and long term. As is the case with many emerging technologies, interviewees highlighted certain barriers to fully implementing AI within their organizations. These included a lack of in-house expertise, low business risk tolerance, and unclear regulatory frameworks. Nonetheless, the majority believed these hurdles to be minor or temporary in nature; many felt that they were navigating AI use and implementation with relative success.

Interviewees also identified barriers for Canadian AI ecosystem growth and FDI attraction. The most significant of these included slow commercialization, the potential for talent drain resulting from high competition for Canada's skilled AI talent (from the US), and slow Canadian regulatory development related to AI. However, none of these challenges were viewed as prohibitive. Instead, according to the interviewees in this study, Canadian AI stands out globally and can be leveraged to attract international investment.

Canada's achievements in AI were generally known by the businesses in this study. About 95% of interviewees were able to relay at least two key Canadian AI developments or advancements, with most highlighting the Scale AI supercluster, the emerging regional hubs (Montreal, Toronto and Edmonton), and top educational institutions such as the University of Toronto, or McGill University offering AI-related programs. Coupled with skilled talent emerging from these and other academic institutions, as well as Canada's ability to attract skilled international talent, interviewees expressed a very favourable view of Canada as a destination for investment. Several interviewees stated that Canada is an "excellent place" for AI investment; many mentioned Canadian developments in the area of responsible AI as both attractive and intriguing.

Canada develops skilled talent capable of innovative AI research, and boasts an immigration system that values and attracts skilled workers from around the world. Combined with innovative educational programs, and a determination by Canadian AI leaders to solve important societal, ethical and economic challenges, investment in Canadian AI is likely to increase. Canada's advancements in talent, research and responsible AI is not going unnoticed. Perhaps especially in this time of uncertainty, Canadian AI has the chance to shine brighter than ever.



INTRODUCTION

The dawn of modern artificial intelligence (AI) goes as far back as 1950 with the development of the Turing Test.⁴ Since then, AI research and development has seen significant advances, leading to numerous applications across sectors and around the world. AI applications are notable in everyday life: they are found in Netflix movie recommendations or Spotify “made for you” playlists, highlighted in Alexa’s vast search capabilities, and even in Snapchat filters,⁵ blending computer vision with augmented reality⁶ to make users look like anything from animals to food products. Although these examples represent some relatively simple applications of AI, businesses around the world are leveraging the technology to improve operations, advance asset management, develop new and innovative products, and manage risk.

Promising developments in AI have resulted in significant global growth in AI research, investment, and product development. Between 1998 and 2018, peer reviewed AI research accelerated by 300%,⁷ and in 2019, global AI investment totalled \$70 billion.⁸ Expanding on ICTC’s 2019 report *On the Edge of Tomorrow: Canada’s AI Augmented Workforce*,⁹ this study investigates AI use cases across seven economic sectors and extracts insights from some of the world’s top business leaders to uncover AI-based FDI-attraction opportunities for Canada.

Section I showcases the state of AI research, ecosystem growth, and investment in Canada and abroad. This section highlights important developments like activities taking place in AI clusters, essential AI research activities, as well as public and private investment trends. Given the current reality of the COVID-19 crisis, this section also provides a snapshot of noteworthy activities taking place during the first months of 2020 as AI innovators strive to develop solutions tied to the pandemic.

Section II presents the key themes and perspectives drawn from interviews with global business leaders in AI. A total of 20 interviews were completed with AI experts (AI engineers, CTOs, CEOs, etc.) from eight countries and across seven sectors. This section offers insight into top business needs solved by AI, interviewees’ knowledge of Canadian AI developments, successes and barriers, and perceptions of Canada as an investment destination.

⁴ “The Turing Test”, *Stanford Encyclopedia of Philosophy*, February 8, 2016, <https://plato.stanford.edu/entries/turing-test/>.

⁵ Anthony Zhao, “The Rise of Artificial Intelligence”, *Impress Magazine*, December 10, 2018, <http://www.impressmagazine.com/the-rise-of-artificial-intelligence/>.

⁶ James Le, “Snapchat’s Filters: How computer vision recognizes your face”, *Medium*, February 6, 2018, <https://medium.com/swlh/snapchats-filters-how-computer-vision-recognizes-your-face-9ce536206fa7>

⁷ Khari Johnson, “AI Index 2019 assessment global AI research, investment, and impact”, *Venture Beat*, December 11, 2019, <https://venturebeat.com/2019/12/11/ai-index-2019-assesses-global-ai-research-investment-and-impact/>.

⁸ *Ibid.*

⁹ Ryan McLaughlin et al., “On the Edge of Tomorrow: Canada’s AI Augmented Workforce”, *ICTC*, December 2019, <https://www.ictc-ctic.ca/wp-content/uploads/2020/02/canadas-ai-workforce-FINAL-ENG-2.24.20.pdf>.



Section III identifies and highlights essential and promising uses of AI across seven sectors: digital technology, advanced manufacturing, natural resources, agriculture and ocean technology, transportation and logistics, life sciences, and business and finance.



Section IV wraps up with an analysis of key informant insights around Canada's attractiveness for AI-based FDI.

A SWOT analysis, showcasing Canada's strengths, weaknesses, opportunities and threats when attracting AI-based FDI is available in **Appendix III**. This analysis, including a combination of insights gained from key informant interviews along with other secondary research, can act as an instrument to assess and enhance strategies for FDI attraction, specific to AI and technology.

THE GLOBAL STATE OF AI: DEVELOPMENTS IN CANADA AND ABROAD

The State of AI in Canada

Canada has become recognized as a thriving hotbed for AI academic research¹⁰; in 2019, Canada was among the top five countries in the world producing innovative AI-based research.¹¹ Sharing this spotlight with nations like US, Japan and the UK, Canada is also becoming a growing hub for AI startups. Home to more than 650 startups, 40 accelerators and incubators, and over 60 research labs,¹² cities like Vancouver, Waterloo, Edmonton, Toronto, Montreal, and Quebec City are beginning to attract attention as up and coming global AI hubs.¹³ A number of these cities are highlighted by interviewees in this study as playing a role in strengthening Canada's AI ecosystem, with three—Montreal, Edmonton, and Toronto—gaining recognition as top AI research and startup hubs in Canada. The following profiles showcase key advancements in these leading Canadian hubs.

¹⁰ "How Canada became a hotspot for artificial intelligence", DMZ Tech Accelerator, <https://dmz.ryerson.ca/artificial-intelligence/>.

¹¹ Gleb Chuvpilo, "AI Research Rankings 2019: Insights from NeurIPS and ICML, Leading AI Conferences", Medium, December 3, 2019, <https://medium.com/@chuvpilo/ai-research-rankings-2019-insights-from-neurips-and-icml-leading-ai-conferences-ee6953152c1a>.

¹² "Canadian AI Ecosystem 2018", jfgagne, May 1, 2018, <https://jfgagne.ai/canadian-ai-ecosystem-2018-en/>.

¹³ *Ibid.*



Edmonton

The UofA Leading the Way

Located in Edmonton, the University of Alberta has rapidly made a name for itself as a top-tier institution for computer science and AI. Home of Canada's first Computing Science department (opened in 1964) the UofA staffs approximately 20 different faculty members who work directly on research related to AI and machine learning.¹⁴ Further bolstering its research strength, the University recently partnered with another Edmonton-based AI trailblazer, the Alberta Machine Intelligence Institute (Amii). The two institutions collaborate on projects such as the creation of a digital chat companion for elderly Albertans,¹⁵ while exploring larger topics in reinforcement learning. Currently, the partnership focuses on areas like game development, clinical decision making, and financial portfolio balancing.¹⁶

Amii Attracting Investment and Supporting Local Ecosystem Growth

Owing to its growing international reputation, large organizations like Google's DeepMind, the Royal Bank of Canada, Mitsubishi Electric, IBM and Volkswagen¹⁷ have all partnered with Amii to conduct research on AI applications and solutions across sectors. At the same time, local startup support groups also work with Amii to grow homegrown talent and accelerate local ecosystem growth. Edmonton.AI works with Amii to enhance Edmonton's AI and machine learning; its mission is to create 100 AI and machine learning companies and projects in the city.¹⁸

The Future of AI Investment in Alberta

In early 2019, the Alberta government announced a plan to invest \$100 million with the goal of attracting global leaders to invest in Alberta¹⁹ as part of its broader economic diversification move. In addition to attracting international investment, this \$100 million was meant to also support domestic ecosystem growth by training over 6,000 Albertans in AI and machine learning and spearheading the development of another 140 AI companies.²⁰ Although it was uncertain whether a provincial leadership change in the summer of 2019 would see this investment reversed, the 2019 fall provincial budget saw no change to funding previously committed for AI research and Amii.

¹⁴ "About the Alberta Machine Intelligence Institute", Government of Alberta, <https://investalberta.ca/organization-items/alberta-machine-intelligence-institute-amii/>.

¹⁵ Andrew Lyle, "Avoiding elder loneliness using artificial intelligence", University of Alberta, October 31, 2019, <https://www.ualberta.ca/science/news/2019/october/avoiding-elder-loneliness-with-ai.html>.

¹⁶ "Reinforcement Learning", University of Alberta, <https://www.ualberta.ca/admissions-programs/online-courses/reinforcement-learning/index.html>.

¹⁷ "About the Alberta Machine Intelligence Institute", Government of Alberta, <https://investalberta.ca/organization-items/alberta-machine-intelligence-institute-amii/>.

¹⁸ "Western Canada's Ecosystem for AI/ML Technologies and Companies", Edmonton.AI, <https://edmonton.ai/>.

¹⁹ "AI in Alberta get \$100M over 5 years", Start Alberta, <https://startalberta.com/news/ai-in-alberta-gets-100m-over-5-years>.

²⁰ *Ibid.*

Montreal

World-Renowned Researchers Abound

Montreal is home to the highest concentration of AI researchers in the world, with over 9,000 students in AI-related programs²¹ alongside several established research professionals. Central to the development of this reputation, McGill University was labelled the 35th top university in the world by QS World University Rankings in 2019. Research output in technology and AI was tagged as “very high.”²² The Montreal Institute for Learning Algorithms (Mila)²³, was founded by AI expert Yoshua Bengio, one of the world’s most cited computer scientists, famous for his work in neural networks and deep learning. Mila is another key pillar of Montreal’s strength in AI research. In 2018, the Turing Award—also known as the Nobel Prize of computing—was given to Mila’s Bengio (alongside French-American Yann LeCun and British-Canadian Geoffrey Hinton).²⁴

Mila and Beyond

Originally founded in 1993 by Yoshua Bengio, Mila strengthened its ties with the Université de Montréal and McGill University in 2017 to scale activity, investment and research in the space of AI. The same year, Mila attracted substantial investment from both government and industry, including global AI leaders like Google and Microsoft. Currently, the Mila community is made up of more than 450 researchers, specializing in areas such as deep learning, bioinformatics, computer vision, and neural networks.

Beyond Mila, Montreal is also home to over 120 AI startups, including Element AI, an organization also founded by Yoshua Bengio. Element AI—Canada’s most internationally recognized AI company—uses AI research to develop enterprise applications.

Supercluster in Action: Scale AI

Part of the Canadian federal government’s supercluster initiative, Scale AI is an AI innovation hub comprised of industry, researchers and promising startups in Canada’s AI ecosystem. With the aim of advancing Canada’s global standing in AI and attracting high-quality investment from abroad, Scale AI received more than \$250 million in funding from the federal government as well as the government of Quebec²⁵ to achieve this goal. The intent of the Superclusters program is to match government funding with private-sector funding.

Scale AI’s mission is to boost productivity across Canada’s economy through the integration of AI, specifically in supply chains. An accelerator of sorts, Scale AI identifies promising projects and businesses across Canada and provides these future leaders with resources, funding, access to investment networks, and other support to scale and grow. To date, Scale AI has supported a total of 14 projects across various industries like retail, natural resources, and digital technology. Combined, these projects received over \$32 million in funding to develop and scale their businesses.²⁶ Ultimately Scale AI’s vision is to see Canada become a global hub for AI development.²⁷

²¹ “Canada – A Leader in Artificial Intelligence (AI)”, Invest in Canada, https://www.international.gc.ca/investors-investisseurs/assets/pdfs/download/Niche_Sector-AI.pdf.

²² “McGill University”, QS Top Universities, 2020, <https://www.topuniversities.com/universities/mcgill-university/postgrad>.

²³ “Quebec artificial intelligence institute: Mila Annual Report”, December 2019, <https://mila.quebec/wp-content/uploads/2019/12/Mila-Rapport-Annuel-2019-v15-EN-single.pdf>.

²⁴ James Vincent, “Godfathers of AI’ honored with Turing Award, the Nobel Prize for computing”, The Verge, March 27, 2019, <https://www.theverge.com/2019/3/27/18280665/ai-godfathers-turing-award-2018-yoshua-bengio-geoffrey-hinton-yann-lecun>.

²⁵ “About Scale AI”, Scale AI, <https://scaleai.ca/about-us/>.

²⁶ Megan Simpson, “Supercluster Scale AI Has Chosen 14 Projects, Invested \$32 Million Since Receiving Funding”, Betakit, January 15, 2020, <https://betakit.com/supercluster-scale-ai-has-chosen-14-projects-invested-32-million-since-receiving-funding/>.

²⁷ “About Scale AI”, Scale AI, <https://scaleai.ca/about-us/>.



Toronto

Epicenter for Canadian AI Startups and Research Advancement

Approximately 250 AI startups call Toronto home. Among them are front-runners like ecobee, a developer of residential smart thermostats, AlayaCare, a cloud-based platform for healthcare practitioners, and Xanadu, a quantum photonic processor and open source software platform.²⁸

Toronto's growing AI presence is strongly backed by already established industries like the financial services sector and world-renowned academics like Geoffrey Hinton and Richard Zemel. A distinguished Canadian professor at the University of Toronto, Hinton is often referred to as the "Godfather of Deep Learning."²⁹ He was named one of the world's top 100 influencers in 2016³⁰ and leads Brain Team Toronto for Google. Zemel, also a computer science professor at the University of Toronto, specializes in machine learning and unsupervised learning. He was selected as the Google/ NSERC Industrial Research Chair for Machine Learning in 2018 and has earned several distinctions in the field of AI, including the NVIDIA Pioneers of AI Award. Together, Hinton and Zemel represent the two leading figures at Toronto AI research and development centre, the Vector Institute. Tasked with advancing the field of AI via research and applications in deep learning and machine learning,³¹ the Vector Institute secured \$135 million in funding in 2017 (over five years).³²

Global Talent and Investment Attractor

Each year, Canada draws in skilled tech talent from around the world. This talent is spread across the country with the highest concentrations in Toronto, Vancouver and Montreal. Toronto, although understated in comparison to many US leading tech hubs, was ranked North America's fastest growing tech hub in 2018 when it surpassed Silicon Valley in tech job creation.³³ With critical support systems like the Creative Destruction Lab, MaRS, and the DCS Innovation Lab, Toronto developed into an important technology hub. Existing research suggests that the city has benefitted from a "brain gain"³⁴ of tech talent from around the world.

With thought-provoking AI research coming out of the University of Toronto,³⁵ coupled with the Vector Institute's research and commercialization in AI, talent attraction has also been closely followed by investors and industry partners. The Vector Institute has developed partnerships with a multitude of organizations such as Scotiabank, Accenture, Shopify and St. Michael's Hospital. Their aim is to advance homegrown AI project development and commercialization. Notably, the partnership with St. Michael's led to the creation of an early warning system for patients in need of transfer to intensive care units (ICUs) at hospitals.³⁶ These applications are critical for maintaining and managing capacity within stressed healthcare systems. With COVID-19 placing unprecedented strain on healthcare infrastructure and ICU capacity, such innovations may prove invaluable.

²⁸ "Artificial Intelligence Startups in Toronto", *Tracxn*, August 2, 2019, <https://tracxn.com/explore/Artificial-Intelligence-Startups-in-Toronto>.

²⁹ "Heroes of machine Learning – Top Experts and Researchers you should follow", *Analytics Vidhya*, July 17, 2019, <https://www.analyticsvidhya.com/blog/2019/07/heroes-of-machine-learning-experts-researchers/>.

³⁰ "The Wired 100", *Wired*, August 26, 2016, <https://www.wired.co.uk/article/wired-global-100>.

³¹ "Vector Institute: Driving excellence in machine learning and deep learning", *Vector Institute*, January 2019, <https://vectorinstitute.ai/wp-content/uploads/2019/02/vector-institute-information-deck-2019m02d13.2.pdf>.

³² "How is the Vector Institute Funded?", *Vector Institute*, <https://vectorinstitute.ai/faq-items/how-is-the-vector-institute-funded/>.

³³ "Toronto tech: why Canada is attracting the 'best' people", *Financial Times*, <https://www.ft.com/content/de63f33c-34e6-11e9-bd3a-8b2a211d90d5>.

³⁴ "Corporate America's visa loss is Canada's brain gain", *Financial Times*, <https://www.ft.com/content/b99c0090-0a01-11e9-9fe8-acdb36967cfc>.

³⁵ "Canada aims to lead world in artificial intelligence", *Financial Times*, <https://www.ft.com/content/3110b1bc-148a-11e7-b0c1-37e417ee6c76>.

³⁶ Ian Gormely, "Vector Institute Kicks off Series of Pathfinder Projects Focused on Health AI Adoption", *Vector Institute*, <https://vectorinstitute.ai/2019/05/06/vector-institute-kicks-off-series-of-pathfinder-projects-focused-on-health-ai-adoption/>.



A New Reality: Key AI Developments in Canada during COVID-19

Canada has seen rapid growth in its AI research over the last number of years. This research has led to the creation of promising startups across the country. With more than 650 AI startups currently in Canada, nearly 30% of this business acceleration was witnessed during 2017–2018. 2018 and 2019 followed with a rapid scaling of international investment in the field of AI; during this period, global giants such as Uber, Google, Facebook and Samsung all established AI research centres and operations in a number of Canadian cities.³⁷

This growth was expected to continue in 2020 but was derailed by the COVID-19 outbreak. Originating in China in late 2019, the global epidemic has now claimed hundreds of thousands of lives. The global economy has not been spared. At the end of March 2020, the S&P estimated a stark and drastic decline economic output, with global growth for 2020 scarcely expected to exceed 0%.³⁸ Naturally, this worldwide crisis has affected the economic outlooks of all industries and governments, leading to colossal priority shifts in supply chains, manufacturing, and investment. Further research is required to truly understand how COVID-19 has and will impact investment prospects for Canada. However, despite the uncertainty, and at times grim reality, Canadian AI innovators and researchers have begun pivoting to develop solutions for this global crisis.

The Ministry of Finance estimates that direct spending on measures to weather the impacts of COVID-19 in Canada will total more than \$100 billion³⁹; this funding includes billions for financial relief like tax deferrals, frozen interest payments, and Employment Insurance, as well as supports for students and new graduates. These initial investments were made alongside partnerships with local businesses to fight the spread of COVID-19 across the country.

At the end of March 2020, the federal government announced new partnerships with Canadian manufacturers and other businesses to produce the necessary medical equipment and supplies needed to curb the spread of the disease across the country. This investment includes \$2 billion in diagnostic testing and the development of ventilators and personal protective equipment (PPE)⁴⁰ desperately needed by healthcare providers in all provinces. Specifically related to areas such as advanced manufacturing, life sciences, and AI, early April 2020 saw a new batch of 49 COVID-19 research projects funded by the federal government, bringing this type of funding to nearly 100 projects and \$55 million.⁴¹ Key post-secondary recipients of this funding include the University of British Columbia (receiving \$1.5 million for two projects) and McGill University (receiving \$500,000 for one project).⁴² Both institutions are developing AI-based tools and technology to combat COVID-19.

³⁷ <https://www.canada175.ca/en/reports/ai-imperative>

³⁸ "Canada's AI imperative: from predictions to prosperity"; Deloitte, 2019, <https://www.spglobal.com/ratings/en/research/articles/200330-economic-research-the-escalating-coronavirus-shock-is-pushing-2020-global-growth-toward-zero-11413969>.

³⁹ "Canada coronavirus measures worth 5% or more of GDP: finance minister", Reuters, April 1, 2020, <https://www.msn.com/en-ca/money/topstories/canada-coronavirus-measures-worth-5percent-or-more-of-gdp-finance-minister/ar-BB122s00>

⁴⁰ "Prime Minister announces new partnerships with Canadian industries to fight COVID-19"; Prime Minister of Canada, March 31, 2020, <https://pm.gc.ca/en/news/news-releases/2020/03/31/prime-minister-announces-new-partnerships-canadian-industries-fight>.

⁴¹ "Government of Canada funds 49 additional COVID-19 research projects – Details of the funded projects", Government of Canada, April 2, 2020, <https://www.canada.ca/en/institutes-health-research/news/2020/03/government-of-canada-funds-49-additional-covid-19-research-projects-details-of-the-funded-projects.html>.

⁴² *Ibid.*

The projects undertaken by these two institutions are the following:



UBC developing a deep learning accelerated docking pipeline (a deep learning algorithm used to virtually screen a commercial 1.3 billion compound library in one week, compared to three years with previous programs)⁴³ to screen millions of “candidate” compounds for a COVID-19 vaccine;

UBC utilizing an existing AI-based virtual healthcare assistant, WelTel, to support home monitoring of COVID-19 cases and contacts;



McGill developing an AI-based news analysis tool to understand how communities and public health agencies are responding to the crisis.

Many leading AI businesses and supporting organizations in Canada are also stepping up to the challenge of the current reality. The Vector Institute, for example, recently produced a list of tools, including open source research and data sets⁴⁴ for anyone interested in contributing to COVID-19 research. This was followed by a rallying of industry sponsors to help free up resources for research on the topic.

Other key examples include software created by Toronto-based BlueDot. BlueDot has developed AI-based “outbreak risk software” that searches news reports, tracks flight paths and other networks to help anticipate the spread and impact of the disease.⁴⁵ After analysis, it sends alerts to its clients—including government agencies, airlines, and hospitals—about the potential spread of the disease. BlueDot claims to have been among the first in the world to identify the emerging risk of COVID-19 in Hubei province.⁴⁶ In light of its success, the Canadian federal government has announced that it will be leveraging BlueDot’s disease analytics platform to help inform continued decision making.⁴⁷

Lastly, banding together in a time of crisis, a special taskforce was created by leaders across Canada’s three main geographic AI hubs to battle the spread of COVID-19. Mila, the Vector Institute, and Amii recently teamed up with researchers from the Canadian Institute for Advanced Research (CIFAR) to work together on AI projects related to COVID-19.⁴⁸ Called “AI against COVID-19” this consortium of experts will focus on projects related to early warning, tracking and prediction, diagnosis and prognosis, as well as treatments and cures. One of the first projects to come out of this partnership is a Mila-inspired “peer-to-peer AI-based system” for tracking COVID-19. The system utilizes machine learning to predict the probability of a person having the virus according to contact history and personal medical information.⁴⁹ Although concerns of data privacy and surveillance are clear with developments like contact tracing, such measures may prove critical in the absence of universal or large-scale testing.

⁴³ “Augmented Discovery of Potential Inhibitors of SARS-COV-2 3CL Protease” UBC COVID-19 Research, <https://covid19.research.ubc.ca/research/augmented-discovery-potential-inhibitors-sars-cov-2-3cl-protease>

⁴⁴ “COVID-19 Updates”, Vector Institute, <https://vectorinstitute.ai/covid-19-updates/>.

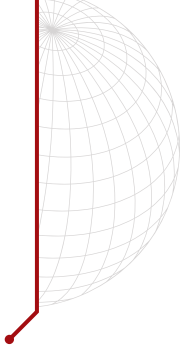
⁴⁵ “BlueDot”, <https://bluedot.global/>.

⁴⁶ Ibid.

⁴⁷ “Canada’s plan to mobilize science to fight COVID-19”, Prime Minister of Canada, March 23, 2020, <https://pm.gc.ca/en/news/news-releases/2020/03/23/canadas-plan-mobilize-science-fight-covid-19>.

⁴⁸ “AI Against COVID-19”, <https://ai-against-covid.ca/>.

⁴⁹ Yoshua Bengio, “Peer-to-peer AI-tracing of COVID-19”, Yoshua Bengio, March 23, 2020, <https://yoshuabengio.org/2020/03/23/peer-to-peer-ai-tracing-of-covid-19/>.



The State of AI Around the World

To say that AI has generated attention around the world would be an understatement. Globally, many nations have taken note of its capacity to boost economic growth, generate never-before seen levels of efficiency and create solutions to important societal challenges, such as the current pandemic. Global investment in AI research, product development and commercialization is ramping, as nations race to develop applications in manufacturing, life sciences, transportation and logistics, law enforcement, etc. Intended as a mere snapshot of crucial advancements in the global race for AI product development, the following sections showcase key advancements in the US, China, and the EU.



AI Developments in the US

Leading Global Market Share

There were an estimated 4,500 public AI companies operational around the world in 2018.⁵⁰ Of this figure, nearly half were located in the US. The closest competitor to the US in terms of sheer volume of businesses was China, with slightly more than 1,000 companies. The impact of US-based AI companies is also notable when it comes to investment; American AI companies were found to generate nearly 50% more funding per investment than AI companies located in China.⁵¹ With the world's largest pool of tech giants able to support investment located in the US, leaders like Google, Intel, Salesforce, IBM, and Microsoft have contributed millions in capital to help scale homegrown AI businesses. In 2019, Intel made a total of 19 investments in US AI startups, followed by Google in second place at 16, and Microsoft in third place with 11 investments.⁵²

In the US, many AI-based products are attractive to consumers. Assistants like Google Home or Amazon Echo are among top-selling gifts, effectively bridging AI and smart home technology through intelligent voice servers.⁵³ Among several other notable AI companies in the US is AEye. AEye is a 2D and 3D perception platform used to run sensors for autonomous vehicles. The company uses machine vision to act as "eyes" for autonomous vehicles, while machine learning algorithms then sort, classify, and respond to objects.⁵⁴

While the US dominates the global AI market in the number of businesses, recent regulatory changes are throwing a wrench into the ability of these products to make their way to customers. In January 2020, regulatory trade restrictions came into effect, requiring US companies that export AI related to geospatial analysis to apply for an export licence for these products.⁵⁵ Although any exports going to Canada are exempt from this process, these new restrictions are believed to have been developed to keep US-created AI technologies away from rival powers, namely China.⁵⁶

⁵⁰ "Number of AI companies worldwide as of June 2018, by country", Statista 2020,

<https://www.statista.com/statistics/941054/number-of-ai-companies-worldwide-by-country/>.

⁵¹ Masha Borak, "China vs. US: Who is winning the big AI battle?" technode, October 22, 2017, <https://technode.com/2017/10/22/china-vs-us-ai/>.

⁵² Reinhardt Krause, "Intel, Google Top Venture Investors in Artificial Intelligence Startups", Investor's Business Daily, March 11, 2020, <https://www.investors.com/news/technology/artificial-intelligence-startups-ai-startups-intel-google-invest/>.

⁵³ Geoffrey A. Fowler, "I live with Alexa, Google Assistant, and Siri. Here's which one you should pick", The Washington Post, November 21, 2018, <https://www.washingtonpost.com/technology/2018/11/21/i-live-with-alexa-google-assistant-siri-heres-which-you-should-pick/>.

⁵⁴ "Aeye", <https://www.aeye.ai/>.

⁵⁵ Liam Tung, "Tech trade ban: Exporting AI is going to get harder, says US" ZDNet, January 6, 2020, <https://www.zdnet.com/article/tech-trade-ban-exporting-ai-is-going-to-get-harder-says-us/>

⁵⁶ *Ibid.*

Strong Support Networks and Educational Institutions

As noted above, the US holds around half of the world's market share in AI; it is currently the undisputed leader in the space. The US is home to numerous growing AI businesses and innovative startups, many of them supported by government agencies like the Department of Justice (DOJ), the Securities Exchange Commission, and NASA. These agencies are currently piloting several AI projects in the US, with recent research highlighting the existence of over 150 use cases across more than 60 US agencies.⁵⁷

Unsurprisingly, the top three AI hubs in the US are synonymous with the largest US tech hubs: San Francisco, New York, and Boston. San Francisco is home to some of the biggest startup incubators in the world, alongside world-renowned institutions like Stanford University's AI Lab, SRI International's Artificial Intelligence Centre (AIC), and Google-NASA's Quantum AI Lab. The Greater Boston region is home to the Massachusetts Institute of Technology (MIT), currently ranked the top university in the world.⁵⁸ Boston is considered to be the second largest US AI hub and the premier location for biopharmaceutical developments. It is also home to institutions such as the Centre for Brains, Minds, and Machines as well as MIT's Computer Science and Artificial Intelligence Laboratory. Finally, New York City is the third largest AI hub in the US, heavily supported by institutions like New York University's Courant Institute of Mathematical Sciences, Facebook's AI Research Group (FAIR), and others.

Key Developments in 2020: US AI Leaders Battling COVID-19

With the US now the global epicentre of the COVID-19 outbreak, many believe that the use of AI in the life sciences sector can play a key role in curbing the spread of the disease. Numerous developments have taken shape in recent weeks to respond to the crisis. Chief among them include, new funding from the US National Institutes of Health (NIH) for researchers and businesses developing solutions to the COVID-19 crisis.⁵⁹ Industry-led initiatives, either independently or in partnership, are also garnering attention. Headquartered in Netanya, Illinois, a company by the name of CLEW uses machine learning and advanced data analytics to build predictive models at the individual patient level.⁶⁰ According to CLEW leaders, this process can be applied to patients in the ICU to improve outcomes and reduce the burden on the healthcare system. Similarly, California-based biotech company BreathResearch utilizes predictive analytics to track respiratory ailments and conditions. To battle COVID-19, the company believes it can provide important data for early detection and treatment via their one-minute pulmonary test.⁶¹ Lastly, tech giants Apple and Google have teamed up to provide information to their users about the spread of COVID-19. Together, the two are working to jointly develop technology that alerts users in the event that they have come into contact with people who have found to be infected with the virus.⁶²

⁵⁷ Stephen Kanowitz, "Where to find AI in federal agencies", GCN Insider Newsletter, March 3, 2020, <https://gcn.com/articles/2020/03/03/ai-use-cases-federal-agencies.aspx>.

⁵⁸ "QS World University Rankings 2020", QS Top Universities, 2020, <https://www.topuniversities.com/university-rankings/world-university-rankings/2020>.

⁵⁹ "Coronavirus Disease 2019 (COVID-19): Information for NIH Applicants and Recipients of NIH Funding", National Institutes of Health, April 14, 2020, <https://grants.nih.gov/policy/natural-disasters/corona-virus.htm>.

⁶⁰ "Clew: The Future of Artificial Intelligence", <https://clewmed.com/>.

⁶¹ "How COVID-19 Is Sparking a New Wave of Health Innovation", Startup Health, March 10, 2020, <https://healthtransformer.co/how-covid-19-is-sparking-a-new-wave-of-health-innovation-a6f09ed1d53f>.

⁶² Leo Kelion, "Coronavirus: Apple and Google team up to contact trace COVID-19", BBC News, April 10, 2020, <https://www.bbc.com/news/technology-52246319>.



AI Developments in the China

Fast Company Growth but Investment Riddled with Ethical Questions

In 2018, around a quarter of the world's AI companies were located in China.⁶³ In addition to a high proportion of researchers and scientists in the country, a significant asset for China in the AI race is the data of its 1.3 billion citizens. These factors coupled with the rapid growth of the Chinese economy seen in recent years may point to a future where China continues to scale its global leadership in AI.

China's top AI companies include SenseTime, a Hong Kong-founded AI SaaS business with offices around Mainland China. SenseTime is currently regarded as the world's highest-valued AI startup⁶⁴ and has received investment from the likes of Qualcomm, Fidelity International, and Hopu Capital. Cloudwalk, another China-based leading AI business, is making inroads in facial recognition technology. Using a combination of machine vision and neural networks, it makes over 1 billion comparisons of faces against its database each day. To date, it has accumulated more than 100 billion data points.⁶⁵ Cloudwalk's platforms have been widely adopted in China.⁶⁶ Proponents of the technology assert that it has been an invaluable resource, helping police arrest over 10,000 criminals,⁶⁷ while others raise important questions about the role of the company—alongside other unicorns, including SenseTime and Megvii—in fuelling the country's omnipresent surveillance network.⁶⁸

Important questions about data use and AI ethics have undoubtedly played a role in China's ability to source international investment. A comparison of industry financing for AI products over the last 10 years in China and the US highlights that although investment has grown in both countries, the US currently receives around three times as much investment as China (nearly \$45 billion in 2017 in the US, compared to under \$15 billion in China).⁶⁹

Emerging Chinese AI Hubs

Of China's more than 1,000 AI companies, approximately 40% are in Beijing, with another 15% in Shenzhen. Beijing's Baidu, and Shenzhen's SenseTime are key successes, helping to bring attention to these cities as international AI hubs.⁷⁰ Hangzhou City, while smaller, has also gained some recognition as being the home of one of the world's largest technology companies, Alibaba. To date, over 1,000 AI patents have been submitted by Hangzhou-based companies.⁷¹ Other emerging AI hubs in China include Shanghai and Hefei, the latter recently establishing China's first national library for "brain-like" artificial intelligence technology.⁷²

⁶³ "Number of AI companies worldwide as of June 2018, by country", Statista 2020, <https://www.statista.com/statistics/941054/number-of-ai-companies-worldwide-by-country/>.

⁶⁴ Bernard Marr, "Meet the World's Most Valuable AI Startup: Chian's SenseTime", Forbes, June 17, 2019, <https://www.forbes.com/sites/bernardmarr/2019/06/17/meet-the-worlds-most-valuable-ai-startup-chinas-sensetime/#654132ff309f>.

⁶⁵ Iris Deng, "This stat-backed AI unicorn has helped Chinese police arrest 10,000 criminals", South China Morning Post, March 28, 2019, <https://www.scmp.com/tech/start-ups/article/3003686/state-backed-ai-unicorn-has-helped-chinese-police-arrest-10000>.

⁶⁶ "Meet China's 5 biggest AI companies", World Economic Forum, September 20, 2018, <https://www.weforum.org/agenda/2018/09/the-top-5-chinese-ai-companies/>.

⁶⁷ Iris Deng, "This stat-backed AI unicorn has helped Chinese police arrest 10,000 criminals", South China Morning Post, March 28, 2019, <https://www.scmp.com/tech/start-ups/article/3003686/state-backed-ai-unicorn-has-helped-chinese-police-arrest-10000>.

⁶⁸ Ibid.

⁶⁹ Masha Borak, "China vs. US: Who is winning the big AI battle?" technode, October 22, 2017, <https://technode.com/2017/10/22/china-vs-us-ai/>.

⁷⁰ Synced, "2017 in Review: 10 Leading AI Hubs", Medium, December 18, 2017, <https://medium.com/syncedreview/2017-in-review-10-leading-ai-hubs-e6f4d8a247ee>.

⁷¹ "Top 10 Chinese Cities for AI Development: Beijing Ranks No.1", Synced, September 9, 2019, <https://syncedreview.com/2019/09/09/top-10-chinese-cities-for-ai-development-beijing-ranks-no-1/>.

⁷² Ibid.

Chinese AI innovation is found in some of the largest technology companies in the world, such as Alibaba and Baidu, as well as promising startups like SenseTime. Based on this growing presence, the availability of skilled talent, and unmatched access to data, some experts estimate that China may surpass the US as the world leader of AI research by 2021.⁷³ Recognizing this potential, China has announced its goal to be global AI leader by 2030.⁷⁴

Key Developments in 2020: Chinese AI Businesses Battling COVID-19

Wuhan was ground zero for the COVID-19 pandemic. Early on, the country focused its AI efforts on combatting the health crisis. Radiological advancements like AI-assisted CT scans were piloted in China, a process that allowed for faster detection of the virus in radiology departments.⁷⁵

As the virus continued to spread across the country, China utilized its “advantages” (access to citizen data, large-scale acceptance of surveillance technology, etc.) to develop new—and many would argue, necessary—interventions. According to the Director General of China’s Cyberspace Administration tasked with international cooperation, China made use of technologies like AI, blockchain and even 5G to battle the COVID-19 pandemic. One example of how China leveraged AI to curb the spread of the infection is in its tracking of public transportation systems using AI-assisted temperature testing. Here, Wuhan Guide Infrared Co. Ltd developed a new temperature measurement technology based on computer vision and infrared technology⁷⁶; it was deployed widely in China for the purpose of identifying those with elevated body temperatures. Those with abnormal body temperatures would then be contacted and advised to self-isolate.

⁷³ Will Knight, “China may overtake the US with the best AI in just two years”, MIT Technology Review, March 13, 2019, <https://www.technologyreview.com/2019/03/13/136642/china-may-overtake-the-us-with-the-best-ai-research-in-just-two-years/>.

⁷⁴ Joe McDonald, “China announces goal of AI leadership by 2030”, AP, July 20, 2017, <https://apnews.com/b43da0d919ee46efb0e185668a2be263/China-announces-goal-of-AI-leadership-by-2030>.

⁷⁵ Julian Liu et al., “Artificial Intelligence Assisted Radiology Technologies Aid COVID-19 Fight in China”, ITN, March 27, 2020, <https://www.itnonline.com/article/artificial-intelligence-assisted-radiology-technologies-aid-covid-19-fight-china>.

⁷⁶ Qi Xiaoxia, “How next-generation information technologies tackled COVID-19 in China”, World Economic Forum, April 8, 2020, <https://www.weforum.org/agenda/2020/04/how-next-generation-information-technologies-tackled-covid-19-in-china/>.



AI Developments in the European Union

Strong Support for Ethical AI Development from the European Commission

As a collective, the European Union recognizes the need to advance research in AI. Under the Horizon 2020 framework for research and development, over €2.5 billion was allocated to AI-related projects in the areas of robotics, big data, health, transportation, and emerging technologies. This initial investment under Horizon 2020 will be followed by €100 billion of funding under Horizon Europe, the EU's forthcoming research and innovation framework program set to launch in January 2021. The details of funding breakdown for AI projects under Horizon Europe are not yet finalized, but the overall program focuses on three key pillars: Excellent Science, Global Challenges and European Industrial Competitiveness, and Innovation Europe⁷⁷—many of these areas are likely to have ties to AI.

In the meantime, other developments have been launched by the European Commission for the purpose of advancing the EU's competitiveness and ensuring that AI developments reflect core EU values. With the EU being a global leader in the analysis of AI from ethical, legal and socio-economic perspectives, the following activities have been undertaken by the European Commission on the topic of AI.

April 10, 2018 Digital Day Declaration⁷⁸—member states sign up to cooperate on AI

April 25, 2018 European AI strategy⁷⁹ is created—leads to an increase in public and private investments totalling €20 billion per year over the next decade to prepare for socio-economic changes and ensure appropriate ethical and legal frameworks

June 1, 2018 AI expert groups are appointed and AI Alliance⁸⁰ is launched

June 6, 2018 Digital Europe program⁸¹ is proposed—€2.5 billion for the deployment of AI

June 7, 2018 Horizon Europe program⁸² is proposed—the largest EU R&D program ever created, totaling €100 billion

December 7, 2018 Coordinated plan within the EU to boost AI made in Europe—all EU countries mandated to develop their own AI strategies by mid-2019

December 18, 2019 Consultation on draft ethical guidelines by AI expert group

⁷⁷ "Horizon Europe – the next research and innovation framework programme", European Commission, https://ec.europa.eu/info/horizon-europe-next-research-and-innovation-framework-programme_en.

⁷⁸ "Digital Day 2019: EU countries will commit to three digital cooperation initiative", European Commission, April 8, 2019, https://ec.europa.eu/commission/presscorner/detail/en/IP_19_2015.

⁷⁹ "Communication from the Commission to the European Parliament, the European Council, The Council, the European Economic and Social Committee and Committee of the Regions", European Commission, April 25, 2018, <https://ec.europa.eu/transparency/regdoc/rep/1/2018/EN/COM-2018-237-F1-EN-MAIN-PART-1.PDF>.

⁸⁰ Cecile Huet, "Artificial Intelligence strategy for Europe", European Commission, July 2018, https://www.ijcai-18.org/wp-content/uploads/2018/07/1_20180717_IJCAI_ECAI_Cecile-Huet.pdf.

⁸¹ "Digital Europe Programme: a proposed €9.2 Billion for funding for 2021-2027", European Commission, June 26, 2019, <https://ec.europa.eu/digital-single-market/en/news/digital-europe-programme-proposed-eu92-billion-funding-2021-2027>.

⁸² "Horizon Europe – the next research and innovation framework programme", European Commission, https://ec.europa.eu/info/horizon-europe-next-research-and-innovation-framework-programme_en.

January 1, 2019 AI4EU project⁸³ is launched

April 8, 2019 European Commission presents its approach to build trust in human-centric AI

April 9, 2019 Digital Day Presentations and discussions on AI ethics guidelines

June 26, 2019 Policy and investment recommendations by AI expert group are provided—the project on AI ethics guidelines enters the pilot phase

February 19, 2020 European Commission launches white paper *On Artificial Intelligence—A European Approach to Excellent and Trust*⁸⁴

The white paper is a prequel to a series of legislation and regulations governing AI. These rules will have far-reaching impacts. Like other European privacy laws, the legislation will apply to anyone who either sells to EU citizens, processes the data of EU citizens, or has European employees. The release of the report has sparked criticism from some industry and policymakers for being too focused on the potential negative uses of AI⁸⁵ and oversimplifying concepts like explainability and offering unclear categorization of low-risk and high-risk scenarios involving AI.⁸⁶

Business Growth and the Emergence of AI Hubs

Europe is considered to have a growing and thriving AI industry, home to over 3,000 companies⁸⁷ across various areas like data analytics, sales, marketing, healthcare, process automation, and image recognition.⁸⁸ The central AI hubs are Stockholm, Amsterdam, and Berlin; Stockholm has approximately 1,166 AI jobs per 1 million people, Amsterdam has 730, and Berlin has 677.⁸⁹ AI leadership has been an objective of the German government for several years now. As early as 2018, Germany launched a large-scale digitization initiative with the goal of eventually helping the country become a global leader in AI.⁹⁰

Notable examples of AI product development and research cooperation exists in the EU and across member states. The MRI Ultrasound and Robotic Assisted Biopsy (MURAB) project has the goal of improving the precision and effectiveness of cancer diagnostics via biopsies with the use of AI. MURAB, with support from the Netherlands, Italy, Germany, and Austria, has reduced biopsy scan times to only 15 minutes from over an hour, and drastically improved the rate of correct diagnoses.⁹¹ Similarly, the

⁸³ "AI4EU", <https://www.ai4eu.eu/>.

⁸⁴ "White Paper On Artificial Intelligence – A European approach to excellence and trust", European Commission, February 19, 2020, https://ec.europa.eu/info/sites/info/files/commission-white-paper-artificial-intelligence-feb2020_en.pdf.

⁸⁵ Smriti Srivastava, "What are the main problems of EU's recently issued AI strategy?", Analytics Insight, February 27, 2020, <https://www.analyticsinsight.net/main-problems-eus-recently-issued-ai-strategy/>.

⁸⁶ Jeremy Kahn, "The problem with the EU's AI strategy", Fortune, February 25, 2020, <https://fortune.com/2020/02/25/eu-a-i-whitepaper-eye-on-a-i/>.

⁸⁷ "Europe Artificial Intelligence Companies", Crunchbase, <https://www.crunchbase.com/hub/europe-artificial-intelligence-companies>.

⁸⁸ Fabian, "The European Artificial Intelligence Landscape: More than 400 AI companies built in Europe", Medium, July 31, 2017, <https://medium.com/cityai/the-european-artificial-intelligence-landscape-more-than-400-ai-companies-build-in-europe-bd17a3d499b>.

⁸⁹ "Top 10 European cities for AI development", Net Imperative, November 16, 2018, <http://www.netimperative.com/2018/11/16/top-10-european-cities-for-ai-development/>.

⁹⁰ "Germany launches digital strategy to become artificial intelligence leader", DW, December 15, 2018, <https://www.dw.com/en/germany-launches-digital-strategy-to-become-artificial-intelligence-leader/a-46298494>

⁹¹ "Using artificial intelligence to detect cancer and other diseases", European Commission, April 9, 2018, <https://ec.europa.eu/digital-single-market/en/news/using-artificial-intelligence-detect-cancer-and-other-diseases>.

AEROARMS project focuses on mechatronic design and control methods for the implementation of aerial robots with arms for grasping objects. In collaboration with Spain, Germany, France, Italy, and Switzerland, AEROARMS has developed the first aerial robotic system with arms capable of advanced manipulation.⁹²

Numerous key developments are notable at the startup level in the EU, with many nations generating AI applications that tackle various sector needs. In early March 2020, CB Insights released its ranking for the top 100 most promising AI startups in the world.⁹³ On this list were six companies located across four EU countries. In France, Heuritech develops a deep learning powered automatic real-time recognition solution for objects, including shapes and people.⁹⁴ KONUX and NavVis are both based in Germany. The former creates smart sensors utilizing advanced analytics to enable predictive maintenance for industrial products, and the latter develops fully managed digital twins. Sherpa, located in Spain, is a dual platform digital assistant using machine learning to anticipate user requirements. Mapillary and PerceptiLabs are both based in Sweden. The former uses computer vision to create better maps, and the latter offers a unique way of building and visualizing models used by data scientists, machine learning engineers, and developers.⁹⁵

Key Developments in 2020: EU AI Leaders Battling COVID-19

With the epicentre of the COVID-19 pandemic hitting Europe in early March 2020, many EU organizations have refocused business needs to fighting the spread of COVID-19. For example, hospitals—both academic and non-academic—expressed willingness to share data to train algorithms via the technique of federated learning. Federated learning allows a model to be trained using data stored at multiple hospitals; it does this without the data ever leaving hospitals or touching a private server.⁹⁶ Separate models are trained at each hospital with local data then uploaded to a central server. When new data is acquired, hospitals can then download the latest master model and upload it with new data—in this process, raw data is never exchanged.⁹⁷ This practice can be used to test a broad sample of patient resistance to drugs and eventually help develop a COVID-19 vaccine.

The AI industry in the EU has banded together to fight COVID-19. The ImaginingCovid19ai.eu project consists of hospitals transferring data to Quibim, a Spanish-based company seeking to improve human health by applying image processing to radiological images—something that will help detect abnormalities caused by disease. Quibim then trains its algorithms to read chest CT scans to test COVID-19 in patients with respiratory disorders. This method is an improvement from previous, PT-PCR tests, which are highly sensitive to viral testing and are currently in short supply.⁹⁸

⁹² "Aerial robotics systems and AI to make checks on industrial pipelines safer", European Commission, April 10, 2018, <https://ec.europa.eu/digital-single-market/en/news/aerial-robotics-systems-and-ai-make-checks-industrial-pipelines-safer>.

⁹³ "AI 100: The Artificial Intelligence Startups Redefining Industries", CB Insights, March 3, 2020, <https://www.cbinsights.com/research/artificial-intelligence-top-startups/>.

⁹⁴ "These 15 European companies are selected among the top 100 promising AI startups in the world", Silicon Canals, March 16, 2020, <https://siliconcanals.com/news/top-artificial-intelligence-startups-europe/>.

⁹⁵ *Ibid.*

⁹⁶ Karen Hao, "A little-known AI method can train on your health data without threatening your privacy", MIT Technology Review, March 11, 2019, <https://www.technologyreview.com/2019/03/11/136710/a-little-known-ai-method-can-train-on-your-health-data-without-threatening-your-privacy/>.

⁹⁷ *Ibid.*

⁹⁸ "Europe seeks to harness power of AI in COVID-19 crisis", Physics World, April 2, 2020, <https://physicsworld.com/a/europe-seeks-to-harness-power-of-ai-in-covid-19-crisis/>.

GLOBAL PERCEPTIONS OF CANADA IN THE AI SPACE

Engaging With Experts: Discussions With Industry Leaders

To inform this study, ICTC completed 20 interviews with key industry experts (including CEOs, CTOs, Directors, and technical leads) from international companies capable of investment. These interviews were critical to extracting in-depth primary research on questions related to AI use cases, investment needs, perceptions of Canada as a destination for investment, and knowledge of Canadian advances in AI. Interviewees were from companies located in eight different countries and across seven different sectors. A breakdown of interviews is available below.

Table 1. Interviews by country (20 interviews)



Table 2. Interviews by industry area (20 interviews)

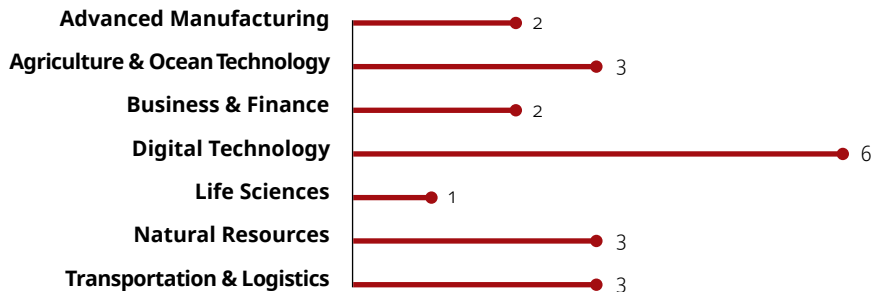
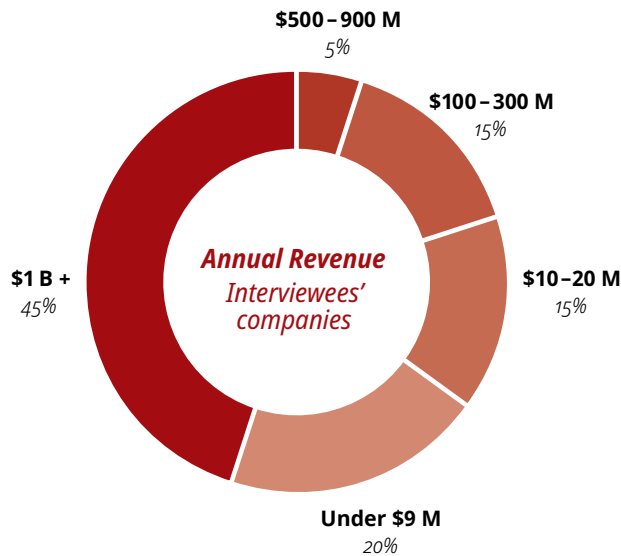


Figure 1. Annual Revenue Buckets in USD (as reported in 2019)

Source: ICTC, 2020.



Interviews with industry experts were critical to informing this research and identifying key themes, which are highlighted below. Categorized under the above seven sectors, interviewees represented companies in the areas of human resources, smart mobility, biotechnology, consulting, media and entertainment, energy, agtech, etc.

Organizations Use Different Types of AI to Respond to Five Key Business Needs

Diversity of AI usage and industry need was evident across the 20 businesses interviewed in this study. Examples range from the use of machine learning and data analytics to optimize pest control in orchards, to the deployment of speech recognition, and NLP to build intelligent navigation systems. While specific business needs and types of AI used varied, a large portion of interviewees asserted relying extensively on machine learning (ML) and advanced data analytics to serve their purposes; a smaller portion stated using deep learning or NLP.

Interviewees asserted that in their businesses, AI was used to solve specific problems or fulfill certain needs. Clear categories emerged around reasons for using AI: product enhancement, improving or optimizing internal processes, improving the customer experience, expanding consulting offerings, and risk management.

Product Enhancement

Half of all interviewees expressed that they were using AI to develop or enhance existing products, while another quarter stated using it to develop new products. These products ranged from automated virtual assistants and advanced driver assistance applications, to chatbots and intelligent platforms for service delivery. Virtual assistants were found to be in the wheelhouse of most companies; many were using them to extract increased output from existing products. One interviewee highlighted the value of their virtual assistant in relation to their intelligent navigation system:



We are building an assistant using machine learning...it is an intelligent navigation device that can play music, use SMS and other apps...[think of it like having] an assistant during [a] car ride, [allowing you] to focus on the road.

— AI Engineer, Transportation, Germany

An assistant like the above can prove useful for providing in-vehicle infotainment (IVI)⁹⁹ while simultaneously mitigating safety concerns associated with distracted driving. Another interviewee highlighted the value of virtual assistants for employee and performance management—a product that the business uses internally and sells to external customers through a license.



We have a new virtual assistant that uses artificial intelligence to answer HR-related questions. [Its] capabilities [allow] organizations to scan its data and pinpoint existing and potentially upcoming people issues like turnover. [With these insights], solutions can be implemented and [businesses] can tackle issues quickly and efficiently.

— CEO, Business & Finance (HR & Recruitment), US

The virtual assistant is a common public-facing instrument to collect data for analysis; other interviewees focused their data collection internally, while investing heavily in advanced data analytics to produce novel insights.

One interviewee, working for a hardware manufacturer, explains how advanced data analytics allowed them to improve product quality and respond to current needs more effectively.



We produce thousands of different products. We used to be a conventional hardware company, but now we can add connectivity and analytics to our products [... this makes] the hardware more intelligent, offers more value from our solutions. [To do this], we need data-driven insights to inform everything we produce.

— Senior Executive (Robotics), Advanced Manufacturing, US

⁹⁹ Vangie Beal, "In-Vehicle Infotainment (IVI)", Webopedia, <https://www.webopedia.com/TERM/I/in-vehicle-infotainment-ivi.html>.

Generating Efficiency and Improving Internal Processes

Around a third of interviewees stated that they were not relying on AI to develop external products or services. Instead, these businesses were putting it to use to improve internal processes and generate efficiencies. Examples include using it to address problems throughout a supply chain and fixing logistical bottlenecks.



AI is the application of data to do insightful things and it is relevant to every business. [As] we have a supply chain, we can face logistical problems that impact customers. Now we have horsepower of technology and AI to address those needs in a smart, quick, easy way.

— Senior Executive, Agriculture & Ocean-technology (Ag-Tech), Australia

Another area of internal efficiency-boosting frequently highlighted by interviewees was asset management. One interviewee from the natural resources sector with operations in Europe notes that even (seemingly small) efficiency boosters can make big differences for energy provision.



We optimize energy systems...boosting efficiency of energy systems [...even] small-scale efficiency gains are important in a very large system. The electrical grid covers the entire globe [...] very small efficiency gains in a very large system is fundamental.

— CEO, Natural Resources (Electricity), Czechia

For another interviewee from the natural resources sector focused on mining and oil and gas extraction, asset management was a high priority and machine learning was key to the process.



We are capital heavy...we have a ton of assets like energy infrastructure and capital assets of various kinds... we need to ensure that these assets are performing well. This is not just for cost effectiveness but also safety and reliability reasons.

— Senior Executive, Natural Resources (Mining), US

For this company, AI-leveraged asset management also included increasing productivity of the company's workforce.



We use insights to take actions [including helping] our own employees be more productive. We take a workforce and move them from what tends to be more traditional approaches of working to modern ways of working, enabled by data and AI.

— Senior Executive, Natural Resources (Mining), US

Efficiency is especially key for certain industries with tight timelines and cyclical content delivery. The video game industry, for example, often requires extremely high periods of productivity before game deployment deadlines, which themselves require the transfer of very large packets of data. For video game developers, discovering errors at the 11th hour, so to speak, can be catastrophic. One interviewee expresses why generating efficiencies as early as possible in the content creation and scoping phase is essential:



We pay a lot of attention to productivity in certain [initial tasks] before moving forward. We have been using AI to assist [content] creators perform certain processes faster. We never set out to entirely automate any processes.

— Director, Digital Technology (Media & Entertainment), France

Improving Customer Experience

Around a fifth of organizations were using AI to improve the customer experience. This was primarily done through machine learning algorithms that analyze data from customers or chatbots and other tools for building business relationships.



A key focus is our all around our external customer experience. We have 4 million customers in distribution, so we use chatbots and other tools to offer the best experience.

— Senior Executive, Natural Resources (Mining), US

Some interviewees expressed more idiosyncratic applications of AI to improve the customer experience. This includes intelligent algorithmic-based apps that help potential customers find the best product or next step in a process, or intelligent pricing algorithms that identify optimal prices in a complex marketplace.

Although the permeation of technology across several sectors of the economy is increasingly becoming an everyday reality, some sectors are more ‘traditional’ in their operations than others. Agriculture was one of the first sectors to embrace technology, adopting it as early as the 1800s with the rise of the Agricultural Revolution.¹⁰⁰ Today, it is much slower to adopt and implement transformative technologies like AI, but interviewees in this sector suggest that doing so can lead to dramatically improved outcomes and better relationships between agricultural companies and growers.



We use [AI] for a few reasons. One is to get a better experience for our customers...we are the only vertically integrated company with mining, manufacturing, and retail...we span the entire process from mining to silo so we can offer critical insights for customers across the crop to harvest lifecycle.

— Senior Executive, Agriculture & Ocean-technology (Ag-Tech), Australia

¹⁰⁰ “The Agricultural Revolution”, lumen, <https://courses.lumenlearning.com/boundless-worldhistory/chapter/the-agricultural-revolution/>.

Despite the opportunity that AI can create for the agriculture sector, one interviewee, whose company specializes in eco-friendly pest control for orchards, stresses that the challenge of implementing technologies like AI in agriculture are largely related to relationship building, not the viability of the technology itself. This interviewee suggests that tools alone are not sufficient to drive adoption.



I believe one of the biggest challenges [with AI] is that [it can be seen] as a hammer and everything else as a nail. For us, [AI] is a tool that provides better insights, helping our customers make better decisions for their orchards...however, customers have questions...you need to be able to explain your data, your tools, your insights. [You] can't just throw data points into an AI algorithm and then present it to a grower. Growers only have one chance per season to get it right, so [they] need to be able to trust what info you are giving them.

— Engineering lead, Agriculture & Ocean-technology (Ag-tech), US

Expanding and Diversifying Consulting Services

Approximately 20% of interviewees expressed that their organizations were providing AI-based applications or AI consulting services to their clients. These services were usually provided to companies that were already using AI to enhance their businesses.

One interviewee in the digital technology sector stresses that AI tools and applications can be key to expanding business offerings, including consulting services.



The company specializes in product development and consulting. In both cases, AI and especially machine learning is used to enhance products as well as provide consulting on the development or implementation of AI. One thing [we] are focusing on is rolling out more sophisticated techniques in machine learning...[we're] creating niche expertise by using AI in image-processing.

— Technical Lead, Digital Technology

Despite the many opportunities, this interviewee underscores that using AI to expand consulting services is not a simple process and can often be met with challenges related to investment and delivery.



We need people who are both technically-skilled and great with the client-facing part of the job. They need to have business knowledge and be capable of developing a product on a very technical level. The client is, in many ways, the domain expert and knows what they need; this needs to be coupled with a team of machine learning experts that are trying to understand those client requirements and build up better solutions. So, you need individuals that have both the machine learning expertise as well as the business acumen that allows you to work between all these groups— [this is what can really drive the field of AI-based consulting].

— Technical Lead, Digital Technology

For companies expressly in the tech consulting industry, AI is increasingly viewed as a core part of the business model. Here, the main role of consulting services is to help unlock the value of AI for their clients and help them monetize deployment. Two interviewees mentioned working with diverse clients to help them incorporate AI to achieve business goals.



As a consulting company, we work collaboratively with clients to leverage their data assets and deliver innovative solutions that drive their drive business value.

— Senior Consultant, Digital Technology (Consulting), Australia



I lead a talented team of professionals that provide advice and support to clients on their AI and AI analytics. AI is the category of 'General Purpose Technology,' and it touches every facet of business and people's daily lives. [...It has the capacity to] drive down production costs and improve performance in many sectors.

— Market Leader, Digital Technology (Consulting), US

Risk Management and Analysis

Around a quarter of organizations noted using AI for monitoring or risk-management purposes. For monitoring asset performance, the methods ranged widely. This included satellite imagery, image-production, data and image analysis, as well as tools to predict and address potential problems.

One interviewee working for a smart mobility company noted that AI was used for general risk management, with specific examples being the monitoring of vehicle issues and ensuring the safety of its clients. In contrast to traditional risk models that are binary in nature, AI algorithms take into account many moving variables. AI models can assess the weight or importance of a given risk at a specific point in time to make informed decisions.



Our promise to clients is to uphold the safety of the community [...] to ensure that clients are trusted, are good drivers and will not cause accidents. [...] We are using a machine learning algorithm that accounts for various factors [...]; we put these in our model and then our model decides, based on our data, how to weigh a given risk.

— Managing Director, Transportation, US

Another interviewee representing a global leader in the advanced manufacturing space, specifically for air travel, stressed that AI is extremely crucial to their business. This interviewee asserts that AI experimentation allows them to avoid risks that have the potential to be catastrophic.



The high-risk nature of some of our work is extremely significant when we talk about implementing AI. We don't build AI models—we build computational decision systems. [In our case] we need to have machines that can make the right decisions in extremely high-risk situations...for companies like [ours], we focus on solving problems where current technology is limited. To do this [right] requires significant experimentation.

— AI Lead, Advanced Manufacturing, US

Most Organizations are New to AI Investment, But All are Optimistic About its Potential

Across sectors, most interviewees asserted that their investments in AI are relatively new. Nearly 60% of interviewees stated that their investment and use of AI began less than five years ago. This was followed by a quarter that had been using it for anywhere between five to nine years, and another 15% that were considered veteran users of the technology, investing in it for over 10 years.

A notable “gulf” was evident between organizations whose businesses have been traditionally tied to technology and those that have not. For the latter, many are still getting their feet wet in the space. One natural resources company in existence for over 20 years noted that although there was always some interest in adopting AI, its actual application is relatively new.



We started actively dabbling in AI years ago, but we really focused in a material way starting in 2018. Today, we are no longer [just] dabbling, but actively creating an environment in which we can invest in a meaningful way to leverage AI capabilities.

— Senior Executive, Natural Resources (Mining), US

Other companies had longer histories of utilizing technology across various aspects of their businesses. For these companies, it was not possible to separate the business from technology—in this case, AI.



[We were] one of the first companies to have an AI research lab, built nearly [50 years] ago. In those days, AI was more symbolic...focused on optimization, planning, scheduling, but [we] had an AI group. [We] were also one of the first companies to have an applied mathematics group.

— AI Lead, Advanced Manufacturing, US

Irrespective of length of experience with the technology, all interviewees asserted their plans to continue to boost these capabilities and search for valuable AI-based investments. Elaborating on these future plans, many interviewees stressed that pursuing AI was not about “tech for tech’s sake” but for specific sector uses cases. Notable examples were provided by interviewees in the natural resources sector, whose businesses were often “newer” to AI than others.



AI in its application is not tech for tech’s sake; it must make our business better, make our employees more productive. [We are implementing it] to do the right thing for our stakeholders.

— Senior Executive, Natural Resources (Mining), US



For us, it's the specific use case that is important. [Some] are focused on using AI for 'boutique' problems like retouching photographs. We need more practical, industry-specific applications that are for [the better] of our sector. We need to get from point A to point B, [but] we are often working in places that don't even have electricity, let alone computing power. We like the idea of using AI as a way to learn and explore new possibilities.

— Global Lead, Natural Resources (Mining), UK

Although there was a strong consensus in favour of AI adoption, interviewees were largely unable to pinpoint the economic value that it brings to their organizations. Only three interviewees were able to provide estimates; two expressed that about 10–25% of their companies' value was found in AI, while the third asserted that AI was inherently tied to all aspects of the business, effectively making up 100% of its value.

Organizations Mostly Face Minor Barriers to AI Implementation

Interviewees largely perceived barriers for AI adoption to be minor. About 80% of interviewees rated barriers to implementing AI as “insignificant.”



[The barriers are] not too significant. There are some difficulties with putting a team together, or some challenges navigating privacy restrictions in European Union, but no major problems on the organizational level.

— AI Engineer, Transportation, Germany



We have no significant barriers in implementing AI. There are small challenges of course, but we are no worse than anyone else. For our size and industry, we are doing well.

— Senior Executive, Agriculture & Ocean-technology (Ag-Tech), Australia

Where barriers were identified, the most common were related to the insufficient availability of talent with organizational expertise in relevant areas. “Cultural reluctance” to an “emerging or risky” technology was also a barrier. On lack of expertise, one interviewee describes the multifactor process that extends far beyond simply creating machine-learning models or designing algorithms.



Talent is a major difficulty. Taking classes online is not enough for the current generation of engineers. Data alone is an increasingly empty word. You need to generate the right data to apply it to the right tools, at the right time with the right level of granularity and noise...and [you need to] ensure it is representative, too... this is all hard.

— AI Lead, Advanced Manufacturing, US

Another interviewee in the consulting space elaborated on the types of talent businesses tend to look for, and why it is often difficult to source.



Talent-wise, many are looking for precise skill levels and they are ramping up very slowly, particularly on the side related to consulting work. Generally, [we] look for specific levels of expertise in AI related to software development...[these are] people with PhDs in math or computer science, and they usually have 10+ years of experience in enterprise application development.

— Technical Lead, Digital Technology

Cultural reluctance was the term used to describe a relatively risk averse or conservative business culture that sometimes comes with the implementation of emerging technologies like AI. Specifically, some interviewees struggled to get buy-in from other executives or customers on the benefits of AI-powered solutions.



In the industry we are in, implementing AI means a cultural change. That's a journey that we have to take—most big companies do. We should eventually be thinking of innovating in everything we do, thinking about how AI can be used to improve all processes, and how it can be naturally applied, not forced. We have not reached that stage yet. We have not quite reached a constant tech-friendly, open, adaptive culture.

— Senior Executive, Agriculture & Ocean-technology (Ag-Tech), Australia

Another interviewee also raised the barrier of culture challenges, extending it to the consumer base.



There is a disconnect between what customers think AI can be and what it really is. Many customers don't realize they already use AI-powered tools.

— Market Leader, Digital Technology (Consulting), US

Most Respondents had Knowledge of Canada in the AI space. Many were Familiar with Key AI Hubs, Canadian cities, the Scale AI Initiative, and Top Educational Institutions

Nearly all (95%) of interviewees were aware of Canadian developments in the field of AI. Most interviewees knew about Canadian cities leading in AI development, Canada's Scale AI Supercluster, and key educational institutions and prominent Canadian AI researchers.

Three-quarters of interviewees were most familiar with Toronto, Edmonton and Montreal as Canada's main "AI hubs." Other cities that were mentioned, although to a lesser degree, were Vancouver (noted by one quarter of interviewees) and Ottawa (mentioned by 15% of interviewees). These cities were known for their high concentration of AI researchers, strong educational institutions, and ability to attract well-known international business, including big players such as Google, Facebook and Microsoft.



We are aware of the Montreal community [and] the well-established Toronto community. These two cities come up most often when we talk about [AI] research.

— Senior Executive (Robotics), Advanced Manufacturing, US



Montreal, Toronto, Edmonton, and Vancouver are the four main hubs for AI in Canada. In Alberta, the University [of Alberta] is also very strong in AI. [...] There are many other groups in other cities. I think Ottawa also has an excellent Machine Learning group.

— AI Lead, Advanced Manufacturing, US

Nearly half of interviewees were also aware of the Scale AI Supercluster initiative. This is a significant difference from a previous ICTC study on FDI where only a handful of digital businesses in the EU expressed some knowledge of the Superclusters and only one interviewee out of 37 was able to name all five.¹⁰¹ In this case, those who were aware of the Scale AI initiative also expressed belief that it can help Canada become a global AI leader—many felt that it sent an important signal to investors that the Canadian government was committed to growing Canada’s AI presence and that Canada is “open for business” on the AI front.



The biggest advantage [of the supercluster] is that it says ‘OK, Canada is serious about AI’.

— CEO, Natural Resources (Electricity), Czechia

Interviewees also recognized the positive reputation and significant progress made by Canadian educational institutions. The University of Toronto, McGill, Université de Montréal, and the University of Alberta were often cited as strong in AI talent development. Out of the three, the University of Toronto was the most frequently referenced as one of the top institutions for AI and engineering talent. Other institutions mentioned include the University of Waterloo and the University of British Columbia.



We think Canada is very strong in terms of academic training—not just Montreal or Waterloo, but more broadly: being able to tap into the education system that grows strong AI talent is key.

— Senior Executive, Natural Resources (Mining), US



Canada has very strong schools for AI and computer engineering: we attract talent from UBC, where we’re seeing an uptick in cloud and engineering graduates. The University of Toronto is a hub of AI— all tech companies recognize that. The quality of talent and education [in Canada] is quite high.

— Engineering Lead, Agriculture & Ocean-technology (Ag-Tech), US

¹⁰¹ Alexandra Cutean et al., “A new partnership with the EU: CETA and digital FDI opportunities for Canada”, ICTC, February 2020, <https://www.ictc-ctic.ca/wp-content/uploads/2020/02/canada-eu-partnership-v2.pdf>.



Canadian universities are putting a lot of focus on AI: McGill, [the University of] Waterloo, the University of Alberta are all doing a lot to produce skilled graduates.

— Senior Executive, Agriculture & Ocean-technology (Ag-Tech), Australia

Canada Recognized for its Growing AI Community, Proactive Immigration System and Ability to Attract Skilled Mid- and Senior-Level Internationally Trained Professionals

While interviewees expressly praised Canada’s educational institutions for producing high-quality talent at the entry level, many also suggested that Canada’s quickly scaling AI community—and specifically its research capability—was being recognized internationally as well.



[Canada has] strong talent and researchers... within the international community, it is established as one of the leaders in research and applied AI.

— AI Lead, Advanced Manufacturing, US



Canada is a very good place for AI. There is excellence in terms of research and talent. Canada also has top minds like [Yoshua] Bengio. The research pedigree [in Canada] is very high.

— Director, Digital Technology (Media & Entertainment), France

The presence of top research expats like Yoshua Bengio and Geoffrey Hinton were asserted to be essential factors accelerating international attention for Canada’s AI ecosystem, alongside the attractive immigration system. Two interviewees expressly stated their belief that Canada is viewed as a top destination for skilled international talent, supported by a skills-first immigration system, and a welcoming and friendly culture.



The overall culture in Canada makes it the most attractive place in the world. If it continues to build the right infrastructure, it can attract the right people with real talent. Canada itself is the right place to do it—the policies it has, the leadership it has makes [it] an exciting place for everyone.

— CEO, Natural Resources (Electricity), Czechia



Canada is a very immigrant-friendly country. If you are an immigrant, it's a good place to be. Local people are sweet and friendly. My sister moved to Canada and found the locals to be very nice, polite and educated. The social life [in Canada] is also nice; not everything is about work. I think Canada is very good.

— AI Engineer, Transportation, Germany

Main Barriers for AI Investment Attraction in Canada were Unclear Regulation, Competition for Talent, and the Small Size of the Canadian AI Ecosystem

Although approximately one-third of interviewees were unable to identify barriers for AI investment attraction specific to Canada, a few clear themes emerged from the two-thirds that did. The most pressing barrier, as expressed by nearly 65% of interviewees, was regulation. Several interviewees felt that regulation around AI development and its use was “unclear” and “not well understood”. One interviewee from the consulting sector highlighted this reality, tying it to the impact of AI development.

/// [There is] unclear regulation around the [development] and use of AI...[there is a] lack of understanding, lack of trust, and lack of awareness [on the issue] and it impacts the ability of Canadian AI companies to scale or draw investment...business struggle to move from experimentation to implementation.

— Market Leader, Digital Technology (Consulting), US

An interviewee from the growing agtech sector highlighted that for them regulation was not currently a concern, although it is pressing for other innovative sectors seeking to implement AI.

/// Policies and regulations have not been an issue for us yet...but as AI develops with autonomous cars, drones, and other applications, it will become more important for Canada to be on top [of this]. We are keeping our eyes on these developments, [but] there is a bit of a chasm right now between regulation and reality.

— Engineering Lead, Agriculture & Ocean-technology (Ag-tech), US

Regulation was also a central concern for the quickly developing life sciences sector, namely in the space of biotech and drug development. One interviewee from this sector specifically highlights the need for regulation and transparency about how public data is being collected and used by AI.

/// [Canada] needs some more regulation...a lot of people don't appreciate what is going on with data. They don't like [the idea of] being tracked or their data being scraped, but we need a lot [more] transparency on what is actually happening. The general public needs to know what is happening with their data, and [potential] misuse of AI and machine learning [needs to be] kept front of mind.

— Lead Scientist, Life Sciences (Biotech), UK

After regulation, over 40% of interviewees identifying barriers expressed at least some concern about competition in the Canadian talent pipeline. Interviewees noted some apprehension about talent recruitment particularly at the senior level, but the greater worry was around retention. Interviewees worried about competition for top Canadian-based talent, namely from the US.



[The] main problem is the competition from San Francisco or Silicon Valley or New York... San Francisco in particular offers better salaries. If I were a new developer, I would go to Silicon Valley. The biggest pain point is competition, specifically with the US.

— AI Engineer, Transportation, Germany

Several interviewees noted the related challenge of big tech outside of and within Canada winning the competition for talent. For international companies who already had a presence in Canada, this challenge was acute.



Big tech companies like Google and Facebook are already disrupting the Canadian market. These are pure tech companies whose meat and potatoes are technologies like deep learning...they are offering practically the same salaries that are available in California—this is much more than the standard for the Canadian market...it can be difficult to get [top] talent, despite the large supply and the great universities.

— Director, Digital Technology (Media & Entertainment), France



While Canada is recognized overall as a key center for AI, a lot of Canadian talent is working for large American companies...the big players like Google, Microsoft, Facebook, and IBM. Those companies have a very strong presence in Canada already, and they attract a lot of top talent. One big challenge is being able to attract and retain people who have appropriate skills around AI—there is a lot of competing with US companies both inside and outside of Canada.

— CEO, Natural Resources (Electricity), Czechia

Lastly, a recent report by the Impact Centre at the University of Toronto found that Canada “dramatically underperforms” in comparison to the US in scaling private companies.¹⁰² This sentiment was echoed by approximately one-quarter of interviewees who expressed investment barriers tied to the small size of the Canadian ecosystem. One interviewee in the smart mobility space made specific reference to this, highlighting the lack of scaleup success among large AI—or technology companies in general—as a key stumbling point for Canada.



Canada is missing big champions in AI and tech. Canada does not have a lot of super big and successful tech companies. This is a bit of a drawback.

— Managing Director, Transportation, US

¹⁰² “Impact Centre Science to Society”, <https://www.impactcentre.utoronto.ca/>.

THE IMPACT OF AI ACROSS SECTORS

AI is having a growing presence across all areas of the economy. In agriculture, AI is increasingly key in detecting diseases in plants, aiding in pest control and, when coupled with data captured from drones, can be essential in identifying farm-wide problems.¹⁰³ Similarly, machine learning algorithms can be combined with historical data on rainfall, temperatures, and evaporation to predict the likelihood of a drought.¹⁰⁴

Fully immersive realities as described in books like *Ender's Game* or *Ready Player One* are not yet possible in video games. However, the growing fusion of deep learning with video game production may result in future games that are far more reactive and adaptive—in 10 or 20 years from now, a game may be able to change and respond to player feedback, and in-game characters might have the ability to evolve in real time,¹⁰⁵ as a human would.

There is no shortage of examples to showcase how AI is altering or can change the economy and the world we live in. Leveraging secondary research and critical insights from interviews with industry experts, the below offers snapshots of AI's impact on seven key sectors of the economy.



Advanced Manufacturing

The current reality of COVID-19 is likely to drastically alter the global state of manufacturing. It remains to be seen how the pandemic will alter worldwide trade and shift international relationships that currently fuel much of the world's global supply chains. However, for some time, traditional manufacturing saw stark declines in many advanced economies. In late 2019, the US manufacturing sector faced steep contraction prompting the worst decline in over a decade.¹⁰⁶ Even if the concept of homegrown manufacturing does make its broad resurgence in places like North America or the EU in the coming months or years, it is hard to imagine such a reality decoupled from a sharp increase in technological efficiency boosters and productivity enhancers. Advanced manufacturing involves adoption of digital technologies—primarily AI, robotics, the Internet of Things, and 3D printing—in the traditional manufacturing process for the purpose of enhancing output.¹⁰⁷ Boosting production, the automation or digitization of manufacturing processes like prototyping, sorting, and even shipping can far outstrip output and existing productivity levels.

¹⁰³ Kathleen Walch, "How AI is Transforming Agriculture", *Forbes*, July 5, 2019,

<https://www.forbes.com/sites/cognitiveworld/2019/07/05/how-ai-is-transforming-agriculture/#2430846d4ad1>.

¹⁰⁴ Himani Shah et al., "Drought Prediction and Management using Big Data Analytics", *Semantic Scholar*, 2017, <https://www.semanticscholar.org/paper/Drought-Prediction-and-Management-using-Big-Data-Shah-Rane/53154867887b8fa060700ff6924aad9053bee0e>.

¹⁰⁵ Nick Statt, "How Artificial Intelligence Will Revolutionize the Way Video Games are Developed and Played", *The Verge*, March 6, 2019, <https://www.theverge.com/2019/3/6/18222203/video-game-ai-future-procedural-generation-deep-learning>.

¹⁰⁶ Anneken Tappe, "America's factories just suffered their worst month in a decade", *CNN Business*, October 1, 2019, <https://www.cnn.com/2019/10/01/economy/ism-manufacturing/index.html>.

¹⁰⁷ "What is Advanced Manufacturing?", *TWI*, <https://www.twi-global.com/technical-knowledge/faqs/faq-what-is-advanced-manufacturing>.

However, the intermingling of AI with manufacturing does not necessarily lead to the full automation of human processes; in many cases, various non-automatable processes will remain and simply be improved with AI. For example, California-based robotics company Drishti (named after the Sanskrit word for “gaze”) does exactly this. Drishti uses cameras equipped with deep learning architecture to generate real-time analytics on human-performed actions.¹⁰⁸ Once the data from these actions is analyzed, AI provides insights into how to further optimize the human production processes.¹⁰⁹

A number of industry experts interviewed in this study emphasized this notion of AI complementing rather than completely replacing existing manufacturing processes. One interviewee specifically highlights how AI can help workers in the manufacturing sector.



We produce tech solutions, both hardware and software, for a wide variety of industries. We have four major domains: air space; building automation; petroleum and performance materials; and productivity solutions...we have a wide variety of products we develop related to worker safety and worker productivity [which use advanced manufacturing techniques]...for example, If we are developing protective equipment like protective shoes, we want to develop “smart” protective shoes that would collect information about whether workers are handling proper weight, how much they walk, tracking if they fall down...

— Senior Executive (Robotics), Advanced Manufacturing, US

Other interviewees highlighted that AI is essential to improving the manufacturing process by helping to pinpoint potential problems in the production line; for example, utilizing predictive analytics to find bottlenecks. On a larger scale, AI-enabled digital twinning can offer a holistic vision of bottlenecks or breakages not just in one production process but across an entire factory. A key development in advanced manufacturing and digital twinning relies on technologies like AI, IoT APIs, and at times augmented and virtual reality¹¹⁰ to synthesize input from a range of sensors; this data is then used to construct a digital replica. The replica of a factory, for example, can be manipulated via numerous machine learning models and algorithms, allowing businesses to determine the efficiency or overall “health” of the factory as well as highlighting bottlenecks and even predicting blockages or faults that may occur in the future. These kinds of insights allow for better planning and significantly reduced downtime. Digital twinning, a central component of Industry 4.0,¹¹¹ is key to accelerating productivity and improving efficiency in the manufacturing sector.

¹⁰⁸ “Drishti”, <https://drishti.com/state-of-human-factory-analytics/>.

¹⁰⁹ Ibid.

¹¹⁰ “Digital Twins in Logistics”, DHL, <https://www.dhl.com/content/dam/dhl/global/core/documents/pdf/glo-core-digital-twins-in-logistics.pdf>.

¹¹¹ Bernard Marr, “What is Industry 4.0? Here’s a Super Easy Explanation for Anyone”, *Forbes*, September 2, 2018, <https://www.forbes.com/sites/bernardmarr/2018/09/02/what-is-industry-4-0-heres-a-super-easy-explanation-for-anyone/#5e1cf44e9788>.

One interviewee from the transportation sector highlights how Industry 4.0 processes enhance their manufacturing processes and improve the quality of products.



We are working on advanced driver assistance and Industry 4.0 applications, particularly in the tow truck industry. [...] the advantages [of AI] include streamlining the manufacturing processes, increasing quality, reducing downtime, and making processes more cost-effective. All of this is needed to stay competitive internationally.

— Research Engineer, Transportation, US



Agriculture and Ocean Technology

Current estimates point to global population growth scaling to nearly 10 billion by 2050.¹¹² This expansion will not come with an increased availability of agricultural land to support the additional two billion people that will inhabit the earth over the next 30 years. Sourcing unique, effective and climate-neutral methods to improve agricultural yields and nutrition will be essential to sustain then accelerate global food chains in the coming years. Couple this with the reality of declining employment in agriculture across the board,¹¹³ and it becomes clear that technological developments including AI will play an increasingly essential role in agriculture.

Many areas of food production typically involve a relatively small number of employees presiding over large cultivation areas. The average size of a farm in Canada totals nearly 780 acres,¹¹⁴ with seasonal workers playing a significant role—accounting for over 60% of all farm work per year.¹¹⁵ Often comprised of large land masses, farms are ideal places to deploy technology like IoT sensors that can collect data on various inputs like weather conditions, soil quality, crop growth, and even animal health.¹¹⁶ This data, usually collected throughout the entire growing season, can then be analyzed by machine learning algorithms to spot abnormalities and allow for enhanced and informed decision making. Possible applications include everything from estimating yield in an orchard, monitoring the health of crops, to pest control, and water management.

Agtech companies using technology such as AI to improve agricultural outcomes are beginning to see uptake in Canada. Winnipeg-based company Farmer's Edge is a "precision-agriculture" company that evaluates data from satellite images and IoT sensors in fields. The IoT sensors capture information on soil, weather conditions, equipment performance, pests, and crop rot. Once collected, AI is used to spot patterns and trends, allowing farmers to make better decisions and take necessary precautions to ensure optimal crop production.¹¹⁷ SomaDetect, another agtech

¹¹² "Growing at a slower pace, world population is expected to reach 9.7 billion in 2050 and could peak at nearly 11 billion around 2100", United Nations, June 17, 2019, <https://www.un.org/development/desa/en/news/population/world-population-prospects-2019.html>.

¹¹³ Max Roser, "Employment in Agriculture", Our World Data, <https://ourworldindata.org/employment-in-agriculture#all-charts-preview>.

¹¹⁴ "Snapshot of Canadian Agriculture: Chapter 1", Statistics Canada, <https://www150.statcan.gc.ca/n1/pub/95-640-x/2011001/p1/p1-01-eng.htm>.

¹¹⁵ *Idem*, Chapter 2.

¹¹⁶ "IoT in Agriculture: 5 Technology Use Cases for Smart Farming (and 4 Challenges to Consider)", Eastern Peak, June 7, 2018, <https://easternpeak.com/blog/iot-in-agriculture-5-technology-use-cases-for-smart-farming-and-4-challenges-to-consider/>.

¹¹⁷ "About Farmer's Edge", <https://www.farmersedge.ca/about-us/>.

company based in New Brunswick, manufactures a suite of sensors and AI-based software that helps dairy farmers measure fat, protein, and other biochemical components found in milk. SomaDetect claims that their AI is even capable of identifying disease-causing bacteria.¹¹⁸

All interviewees from the agriculture sector agreed that AI is capable of producing significant benefits for the sector. One interviewee explains how AI yields benefits for them but stresses that in agriculture technology's value cannot be divorced from traditional "boots-on-the-ground" methods.



Our AI platform helps farmers make decisions based on data collected from crop sites; it makes predictions around pests, diseases, weather, temperature and humidity. We use machine learning to aid in our pest counting [and...] analyze the images obtained from the crop sites, [...] Ag-tech is a very interesting space because growers are generally conservative and not really 'into' tech. It takes time to gain their trust. AI is no doubt an important part of our business, but half of our organization is boots on the ground, in the orchards—the growers need to trust us before buying any technology.

— Engineering Lead, Agriculture & Ocean-technology (Ag-Tech), US

Undoubtedly, crop management and pest control are big parts of the growing agtech sector. However, another area where AI can play a significant role is in the space of environmental monitoring, such as water management and flood detection. Similar to placing sensors in fields and using machine learning to analyze data on crop health, the same can be done to monitor water levels and predict the likelihood of floods. In these cases, real-time data on water levels and weather patterns collected from remote sensors can be analyzed by machine learning models to generate a "risk assessment"¹¹⁹ at key points in time like during rainy seasons. Technology like this is of utmost importance for countries like the Netherlands where approximately one-third of the country is below sea level.¹²⁰ Moreover, as climate change and rising sea levels function to increase the likelihood of severe flooding¹²¹ around the world, AI-enabled flood detection and mitigation will be key.

One interviewee from the Netherlands explains how AI plays a critical role in their water management and flood detection program.

We deal with the maintenance of water quality, the maintenance of waterways, and the maintenance of water levels. Our AI programs helps us monitor the state of the dyke, for example. From satellite pictures, we can collect images that help us determine the structure of the dyke. Then we can use AI algorithms that show how we can make better dams and ensure that our water maintenance is more effective. We use neural networks to learn where the water is rising and where water quality might be compromised.

— Digital Innovation Lead, Agriculture & Ocean-technology (Ag-Tech), Netherlands

¹¹⁸ "How Our Sensors Work", SomaDetect, <https://somadetect.com/somadetect-how-it-works>.

¹¹⁹ Mohammed Khalaf et al., "Advance flood detection and notification system based on sensor technology and machine learning", IEEE Xplore Digital Library, November 2, 2015, <https://ieeexplore.ieee.org/document/7314188>

¹²⁰ <https://www.netherlands-tourism.com/netherlands-sea-level/>.

¹²¹ Melissa Denchak, "Flooding and Climate Change: Everything You Need to Know", NRDC, April 10, 2019, <https://www.nrdc.org/stories/flooding-and-climate-change-everything-you-need-know>.



Business and Finance

Financial advisers, investment bankers, tax advisers, and human resources professionals are part of a broad business and financial services sector that often leverages large amounts of data to make informed decisions. Although much financial advice is still provided by humans, automated and algorithm-based financial and business products like robo-advisers are gaining significant ground and are attracting attention in Canada and abroad.

Current estimates by the World Economic Forum suggest that half of all stock market trading done today is completed at least in part by automated algorithms that rely on indices derived from trading done by other algorithms.¹²² With the increasing sophistication of AI algorithms and the advent of big data, that figure may continue to rise in the coming years.

Another area where AI is playing a key role is in the realm of human resources. Here, AI applications are used in the recruitment process, employee performance management, and learning and development.¹²³ Recently, many uses of AI in human resources have exposed clear concerns related to training data¹²⁴ as well as biases reflected by machines that rely on this inherently flawed data. However, some companies, such as Sweden's Furhat Robotics, claim that AI can be useful for interviewing candidates because they are not subject to unconscious biases and prejudices¹²⁵ like human interviewers are. For this reason, Furhat created Tengai,¹²⁶ a human-like female AI that interviews candidates. Launched in early 2020, the ability of Tengai to remain truly unbiased remains to be seen.

One interviewee from a human resources company noted the benefit of AI in the recruitment process but went further to express its viability in resource management and dealing with people issues.



We have a new automated virtual assistant that uses artificial intelligence to pinpoint specific existing and upcoming people issues. [This data] can help us create solutions can to tackle [the issues] quickly and efficiently. For example, issues like health risks, benefits costs and employee turnover [...] We are partnering with [other firms] to see if we can improve this process further.

— CEO, Business & Finance (HR & Recruitment), US

¹²² Steven Pearlstein, "Has automated trading hijacked the stock market?", World Economic Forum, February 8, 2018, <https://www.weforum.org/agenda/2018/02/has-robot-versus-robot-trading-hijacked-the-stock-market>.

¹²³ Jeanne Meister, "Ten HR Trends in the Age of Artificial Intelligence", Forbes, January 8, 2019, <https://www.forbes.com/sites/jeannemeister/2019/01/08/ten-hr-trends-in-the-age-of-artificial-intelligence/#4d2dbd483219>.

¹²⁴ Jeffrey Dastin, "Amazon scraps secret AI recruiting tool that showed bias against women", Reuters, October 9, 2018, <https://www.reuters.com/article/us-amazon-com-jobs-automation-insight/amazon-scraps-secret-ai-recruiting-tool-that-showed-bias-against-women-idUSKCN1MK08G>.

¹²⁵ Dr. Pragya Agrawal, "Here is How Bias Can Affect Recruitment in Your Organization", Forbes, October 19, 2018, <https://www.forbes.com/sites/pragyaagarwaleurope/2018/10/19/how-can-bias-during-interviews-affect-recruitment-in-your-organisation/#ea164451951a>.

¹²⁶ "Tengai", <https://www.tengai-unbiased.com/>.

Because the business and financial sector is so broad, there are countless examples of AI applications that can generate substantial impacts. While many such applications are currently theoretical in nature, one clear area where AI has already made notable impacts is in financial auditing, including fraud detection and credit valuation. Vancouver-based Finn AI leverages AI-based financial assistants to tackle a variety of challenges, including money management and loss prevention. Similarly, Ottawa-based MindBridge AI specializes in financial risk management via the deployment of the world's first AI-powered auditor. Finn AI's technology has been adopted by a range of banks including BMO and ATB Financial.¹²⁷ MindBridge AI is used by numerous organizations around the world. Owing to this success, the latter has recently opened its first European office in London, UK.¹²⁸



Digital Technology

Applications for AI in the digital technology (ICT) sector are especially diverse. This sector can include anything from tech consulting, media and entertainment, telecommunications, etc. Oftentimes, companies in this space can have more than one application for the technology, across a number of products. For example, the iPhone's Siri is an NLP-based human-like assistant that is available in over 20 languages. At the same time, iPhone applications like Apple Maps also use optimization algorithms based on machine learning; the new Face ID feature makes use of this as well as facial recognition technology¹²⁹ to automatically "log in" iPhone owners. Beyond the iPhone, Apple's Overton AI is a prototype that can automate basic AI lifecycles by generating numerous models capable of supplying answers to a range of questions.¹³⁰ To date, it is estimated that Overton-based apps have answered billions of questions and analyzed trillions of records.¹³¹

Digital media is a fast-growing space where AI can be applied to improve the experience for both users and content creators. Vancouver-based Broadband TV (BBTV) provides end-to-end solutions for managing, distributing, and monetizing video content. In just 14 years, it has grown to become the second largest video property worldwide in terms of unique viewers after Google.¹³² Part of BBTV's success is its embrace of machine learning, digital signal processing, and big data, which it has used to build software suites for managing content. In Ontario, Toronto startup Sodatone draws on big data analytics and machine learning to allow artists and record labels to track streaming, social media, touring, charts, and playlist data all on one platform. Similarly, established streaming platforms like Netflix and Spotify extensively use machine learning algorithms to improve their services and provide personalized recommendations to listeners or watchers based on their choices. This enhances the entertainment experience for users and, in some cases, encourages them to upgrade to the premium versions of the services.

¹²⁷ "Finn AI", <https://www.finn.ai/solutions/>.

¹²⁸ "MindBridge announces opening of new office in London, United Kingdom", *MindBridge AI*, March 10, 2020, <https://www.mindbridge.ai/press-releases/>.


¹²⁹ Tim Simonite, "Apple's Latest iPhones Are Packed with AI Smarts", *WIRED*, September 12, 2018, <https://www.wired.com/story/apples-latest-iphones-packed-with-ai-smarts/>.

¹³⁰ Kyle Wiggers, "Apple details Overton AI development tool, whose models have processed 'billions' of queries", *Venture Beat*, September 13, 2019, <https://venturebeat.com/2019/09/13/apple-details-overton-ai-development-tool-whose-models-have-processed-billions-of-queries/>.

¹³¹ *Ibid.*

¹³² "BBTV", <https://www.bbttv.com/about>.


One interviewee from a global videogame company discusses how AI is used to optimize the production process.

 *AI is being used in a range of areas in the game development process. [...] Machine learning has a large impact on the craft of game-making. When you create assets by hand, it's expensive and time consuming, but now, AI-based tools can be used to generate new and diverse content, automatically.*

— Director, Digital Technology (Media & Entertainment), France

The growing presence of AI is also creating new opportunities and considerations for consultancies. In 2018, Deloitte launched its AI practice (Omina AI), while other firms like Accenture, KPMG, PwC and McKinsey & Company¹³³ are also boosting their expertise in the space of AI consulting. Consultancies might use AI in their own organizations for the same reasons as other businesses do—for analyzing big data to augment decision making, streamline processes, or incorporate new practices. However, as AI is increasingly used across a variety of industries, many consultancies are serving clients that have a desire to implement AI in their businesses.

One interviewee from an Australian consultancy outlines the business lines that AI has opened for them.

 *We are a consulting company working collaboratively with clients to leverage their data assets and deliver innovative solutions that drive their business value. Our five core pillars are: data and analytics; AI; digital transformation; consumer engagement; and cloud technology. We work primarily with tier-1 and tier-2 companies across a variety of industries including financial services, telecommunications, and public administration [...] We work with clients to improve their business practices and outputs, with AI being a core pillar of the business model.*

— Senior Consultant, Digital Technology (Consulting), Australia



Life Sciences

The provision of new and innovative healthcare services and the formulation of new drugs (via biotechnology) are data and analytically intensive. The life sciences sector—encompassing areas like biotechnology, microbiology, and genealogy—stands to benefit substantially from the implementation of AI.

AI is increasingly being harnessed to improve diagnosis and the patient experience. Toronto-based ConversationHEALTH offers a SaaS suite of messaging apps, websites, voice devices, and banner ads that gives healthcare companies the ability to enter the “conversational age”—the company estimates that in 2020, 85% of user-brand interactions will be through chatbots. Users of the suite can track medication intake, schedule appointments, and receive medical advice.¹³⁴ Swift Medical, also based

¹³³ “The Forrester Wave: AI Consultancies, Q3 2019”, Forrester, September 16, 2019, <https://www.forrester.com/report/The+Forrester+Wave+AI+Consultancies+Q3+2019/-/E-RES146756#>.

¹³⁴ “conversationHEALTH”, <https://www.conversationhealth.com/>.

in Toronto, is another life sciences business that uses AI to identify the severity of wounds and speed the healing process. Founded in 2015, Swift Medical is used by over 2,000 medical facilities.¹³⁵ In BC, Vancouver-based telecommunications giant Telus has developed an application called Babylon that uses a chat-style symptom checker powered by AI to streamline the diagnosis process. With the COVID-19 pandemic throwing telehealth into the spotlight,¹³⁶ apps like Babylon enable users to communicate directly with doctors, providing diagnosis, referrals, and even prescriptions.¹³⁷

Although only one interviewee was sourced from the life sciences sector for this study, this representative from a global biotechnology firm asserted that AI presents numerous possibilities for the sector. However, in the process, it was made clear that AI's role should complement the skillsets and knowledge of existing healthcare practitioners, not replace them.



AI isn't artificial intelligence [in healthcare], but more augmented intelligence. We are not replacing technical people and scientists; we are augmenting and complementing their existing skills.

— Lead Scientist, Life Sciences (Biotech), UK

This blend of traditional scientific occupations and technology is something that businesses like Toronto-based Deep Genomics is trying to make commonplace. A life sciences company using AI to complement existing research on genetics and genomics, Deep Genomics aims to develop genetic medicines with a high rate of success,¹³⁸ faster, and more effectively

Similarly, global pharma leader AstraZeneca is also embracing AI. Using it to generate “knowledge graphs,” AstraZeneca uses machine learning to predict whether a medicine is likely to be harmful prior to clinical trials. This process allows the company to discover and discard drugs that are “duds” early in the process, reducing wasted resources in R&D and mitigating potential harmful effects to humans.¹³⁹

Lastly, related to drug testing, recent months have seen significant activity in the area of vaccination research as well as viral testing. COVID-19 is spreading quickly across the globe and Canada has not been spared. With community transmission now the leading cause of infection in the country,¹⁴⁰ the demand for increased testing with faster results mounts. Some progress is evident. Ottawa-based Spartan Health had recently developed a portable COVID-19 tester (Cube), utilizing AI to analyze DNA received from a swab test.¹⁴¹ Once dropped into the DNA analyzer, the Cube

¹³⁵ “Swift”, <https://swiftmedical.com/>.

¹³⁶ Lee H. Schwamm, “Can telehealth help flatten the curve of COVID-19?” Harvard Health Publishing, March 24, 2020, <https://www.health.harvard.edu/blog/can-telehealth-help-flatten-the-curve-of-covid-19-2020032419288>.

¹³⁷ “Babylon by Telus Health”, <https://www.telus.com/en/bc/health/personal/babylon?linktype=ge-meganav>.

¹³⁸ “Deep Genomics”, <https://www.deepgenomics.com/platform/>.

¹³⁹ Claus Bendtsen et al., “How data and AI are helping unlock the secrets of disease”, AstraZeneca, November 1, 2019, <https://www.astrazeneca.com/what-science-can-do/labtalk-blog/uncategorized/how-data-and-ai-are-helping-unlock-the-secrets-of-disease.html>.

¹⁴⁰ Maryam Shah, “65% of reported COVID-19 cases in Canada related to community transmission: latest data”, Global News, March 28, 2020, <https://globalnews.ca/news/6747218/coronavirus-canada-community-transmission/>.

¹⁴¹ “Ottawa company readies a quick COVID-19 test”, Canadian Healthcare Technology, March 25, 2020, <https://www.canhealth.com/2020/03/25/ottawa-company-readies-a-quick-covid-19-test/>.

yields results in 30 minutes. Although Health Canada originally provided approval for Spartan to begin deploying the Cube,¹⁴² recently Spartan voluntarily paused shipment of the test after Health Canada expressed concerns about its effectiveness in real-life versus laboratory settings.¹⁴³



Natural Resources

Arguably, the mainstreaming of AI is a cornerstone of the gradual transition to a largely service-based economy, however, resource extraction remains an essential sector for global prosperity. Canada depends extensively on its natural resources sector—including energy, mining, oil & gas and forestry. In 2018, natural resources directly and indirectly accounted for over a sixth of Canada's total GDP. The largest sectors in order of importance are energy, mining, and forestry.¹⁴⁴ The prominence of resource extraction has seen notable decline with global shocks such as the recent international oil price war and COVID-19. Canadian oil prices have tumbled,¹⁴⁵ however, with this decline comes opportunity.

Each natural resources subsector involves numerous specific tasks and steps including site surveys, quality control, pricing, and shipping. For many businesses, a large majority of these steps have already been automated to some degree¹⁴⁶ and stand to be further disrupted by the increasing use of AI. Around the world, businesses in the natural resources sector are beginning to embrace digital technologies as a means of reducing environmental impacts and costs while increasing safety. The opportunity to continue to leverage technology for these ends may shine brighter as a result of the current global economic slowdown, which has had colossal impact on employment in the sector¹⁴⁷ as well as unintended but welcome consequences for the environment.¹⁴⁸

One interviewee from a global mining company shares plans for integrating AI to improve the safety of employees while optimizing existing processes.



We have a roadmap of where we want to go in the future. The goal is, overall, to move into intelligent automation of tasks and services. We also want to be able to use AI to monitor safety and wellness. In mining specifically, it will be more about how to optimize the [natural resources] process.

— Global Lead, Natural Resources (Mining), UK

¹⁴² "Health Canada approves Spartan Bioscience's portable COVID-19 test", *National Post*, April 13, 2020, <https://nationalpost.com/pmn/news-pmn/canada-news-pmn/health-canada-approves-spartan-biosciences-portable-covid-19-test>.

¹⁴³ "Rapid test for COVID-19 recalled after Health Canada expresses concerns", *CTV News*, May 3, 2020, <https://www.ctvnews.ca/health/coronavirus/rapid-test-for-covid-19-recalled-after-health-canada-expresses-concerns-1.4922786>

¹⁴⁴ "10 Key Facts on Canada's Natural Resources", *Natural Resources Canada*, 2019, <https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/emmc/pdf/2019/2019-KFF-EN.pdf>.

¹⁴⁵ Hannah Jackson, "Coronavirus: How is the COVID-19 outbreak affecting gas prices in Canada?" *Global News*, March 9, 2020, <https://globalnews.ca/news/6649509/coronavirus-gas-prices-canada/>.

¹⁴⁶ "Report from Canada's Economic Strategy Tables: Report – Resources of the Future", *ISED*, October 2018, <https://www.ic.gc.ca/eic/site/098.nsf/eng/00026.html>.

¹⁴⁷ Sean McIntosh, "Alberta Premier expects oil and gas employment number to become 'much, much worse'", *Eckville Echo*, April 9, 2020, <https://www.eckvillecho.com/news/alberta-premier-expects-oil-and-gas-employment-numbers-to-become-much-much-worse/>.

¹⁴⁸ Paul Caine, "Environmental Impact of COVID-19 Lockdowns Seen from Space", *WTTW*, April 2, 2020, <https://news.wttw.com/2020/04/02/environmental-impact-covid-19-lockdowns-seen-space>.

Numerous advances are possible with the integration of AI in the natural resources sector. In the forestry industry, for example, machine learning has been used to improve the speed and accuracy of analyzing tree species, estimating wood volume, and measuring tree dimensions.¹⁴⁹ Vancouver-based PhotoSat offers the world's only engineering satellite surveying service for the mining, energy, and forestry industries. PhotoSat uses machine learning algorithms to transform pictures taken from satellites into 3D models of worksites.

The broad area of energy production can also be drastically altered by AI, with energy grids being one of the clearest examples. As the global population grows, so will our consumption of energy. Energy will need to be effectively captured, stored, and utilized as and when needed. Smart grids powered by AI can be a key component for reliable energy infrastructure. For example, AI-equipped smart grids can function similarly to a digital twin by blending historical data with advanced analytics capabilities and machine learning to highlight areas needing maintenance and attention early on. As our demand for energy consumption grows, smart grids will help avoid service interruptions and major challenges like blackouts.¹⁵⁰

One interviewee running a global grid maintenance platform highlights how AI helps to ensure that assets are well used, efficient, and can help customers move toward a renewable energy future.



We deal with huge amounts of data, so a lot of the routine data-processing and corrections are done with machine learning algorithms. We are not a company that is developing AI; we are using machine learning techniques to help advance and optimize the energy grid in specific ways...we work with very large industrial customers and we help them stitch together the entire grid of renewables, electric vehicles, etc. Our goal is to help companies transition to clean, renewable energy and make the world a little cleaner and greener.

— CEO, Natural Resources (Electricity), Czechia



Transportation and Logistics

AI can be used in a variety of ways to improve transportation, logistics, and supply chains. For example, it can be utilized to automate large warehouses. Such is the case of Ocado, a supermarket chain in the United Kingdom. Ocado uses a robot called the “hive-grid-machine,” which can execute 65,000 orders per week. The machine dramatically reduces labour costs and time while optimizing the movement of items to their final destinations.

Attabotics, a robotics supply chain company headquartered in Calgary, manufactures a modular all-in-one supply chain product that claims to reduce warehouse needs by 85%; it replaces warehouse shelving with vertical storage structures attended by robotic shuttles.¹⁵¹

¹⁴⁹ Peter Taillon, “Artificial Intelligence and the Forestry Sector”, ICTC, October 31, 2019, <https://www.ictc-ctic.ca/artificial-intelligence-forestry-sector/>.

¹⁵⁰ Herman K. Trabish, “How does AI improve grid performance? No one fully understands and that's limiting its use”, Utility Dive, November 14, 2019, <https://www.utilitydive.com/news/how-does-ai-improve-grid-performance-no-one-fully-understands-and-thats-l/566997/>.

¹⁵¹ Amanda Stephenson, “Robotic logistics company ATTabotics awarded \$4.5M from city's \$100M fund”, Calgary Herald, December 13, 2018, <https://calgaryherald.com/business/local-business/robotic-logistics-company-attabotics-inc-awarded-4-5m-from-citys-100m-fund>.

In transportation, AI is a critical component of smart mobility developments such as intelligent traffic monitoring, and autonomous vehicles. Google's Waymo, for example, has recently launched the world's first commercial taxi service with self-driving cars in Arizona. The company, along with Tesla, is also working on building driverless trucks. Tesla's newly unveiled Semi truck features an "enhanced autopilot" system that uses AI to help avoid collisions while improving lane positioning and rollover protection.¹⁵²

Although AI is a significant component of future-looking smart mobility options like autonomous vehicles, many transportation-based businesses are also currently using AI to generate efficiencies, improve road conditions and manage traffic flow. "Traffic AI" refers to any application of AI in traffic systems.¹⁵³ Data is collected from connected traffic systems, such as lights, bridges or other infrastructure, and machine learning is used to analyze this data against current and historical traffic behaviour in a given area to suggest "solutions"¹⁵⁴ to problems like bottlenecks or congestion.

Other smart mobility developments like ride hailing or ride sharing also make extensive use of AI to optimize rides, chart the most effective routes, integrate customer feedback mechanisms and, ultimately, provide the best possible in-car experience.

One interviewee from a global ride-sharing company highlights the value of AI for the business, making specific mention of matching demand for services with available supply.



[One place] where I see the most value for AI [...] is in the marketplace, matching supply and demand. [This includes] showing people the right cars in the right place at the right time [something that can be a challenge]. This problem can be decreased through a process where people can select their specifications and an algorithm efficiently matches them [according to their needs].

— Managing Director, Transportation, US

For ride sharing and ride-hailing applications, consumer satisfaction and safety are important considerations. This is an area where AI can also play a role. Uber, for example, has recently created an AI-enabled chat function, One-Click Chat. This chat function works in the following way: once a passenger writes a message to the driver, it gets sent to Uber's machine-learning platform which uses Natural Language Processing to preprocess the message and provide scores or predictions on possible intent.¹⁵⁵ Based on assumed intent, it provides three or four suggested replies to the driver, who can validate one and send it back to the passenger with a single click.¹⁵⁶ One-Click Chat allows instant and clear lines of communication between passenger and driver. Another example is the rating feature. Using data collected on reviews of numerous trips from various people, a "profile" is generated of both the driver and passenger. This profile helps to remove ambiguity related to driving records, car cleanliness, punctuality, and other areas that affect the driving experience and influence safety.

¹⁵² "Tesla Semi", <https://www.tesla.com/semi>.

¹⁵³ "Traffic AI: A Real-Life Use Case", HERE Mobility, <https://mobility.here.com/traffic-ai-real-life-use-case>.

¹⁵⁴ Ibid.

¹⁵⁵ Synced, "How Uber & Lyft Use AI to Improve Ride Experience", Medium, July 8, 2019,

<https://medium.com/syncedreview/how-uber-lyft-use-ai-to-improve-ride-experience-f7ffc722dedc>.

¹⁵⁶ Ibid.

ROLLUP: IS AI A VEHICLE FOR ATTRACTING FDI INTO CANADA?

Canada is becoming increasingly well-known as a global hub for AI, boasting some of the highest per capita concentration of AI researchers and scientists. Interviewees in this study regarded Canada particularly well as a destination for AI investment, owing largely to its growing research strength and advances made in key regional hubs. Nearly all interviewees were aware of Canadian developments in AI, highlighting the availability to skilled talent and strong research capacity as critical pull factors for investment. A clear majority of interviewees felt that Canada was not only a favourable destination for FDI in AI, but also specifically indicated interest in Canada for their own investment strategies. Although some barriers such as unclear regulation or concerns over talent retention exist, many interviewees felt that Canada was a top contender for AI-based FDI and noted that Canada can make a significant contribution to the global AI ecosystem.

The below are a few key factors that were highlighted by interviewees as relevant to Canada's ability to attract AI-based FDI.

Skilled Canadian AI Talent a Key Pull Factor

The availability of skilled AI talent in Canada was identified as a top factor incentivizing AI-based FDI by interviewees in this study. Nearly all interviewees (95%) were aware of at least some key developments in the Canadian AI space, with many of them citing top educational institutions such as the University of Toronto, McGill University, and the University of Alberta as top-notch educational institutions developing skilled talent. This talent was regarded as critical to advancing Canadian AI research and commercialization.

Moreover, interviewees expressed knowledge of organizations like the Vector Institute in Toronto, Mila in Montreal, and Amii in Edmonton, each possessing a strong base of skilled AI research talent.

Capacity to Attract Skilled International Talent is Compelling

With its welcoming culture and liberal immigration system that prioritizes skilled talent, interviewees felt that Canada was very capable of attracting skilled internationally trained talent. This was especially highlighted in contrast with the more conservative immigration policies of the US. Interviewees noted that this more liberal immigration system—along with streamlined processes like the Global Skills Strategy that processes eligible work permits within two weeks—provide Canada a significant advantage in attracting AI-skilled international talent, including workers at the mid and senior levels.

Regional Hub Development

Also acting as an attractor of international talent as well as a possible incentive for domestic talent retention, interviewees mentioned several AI hubs in Canada. While the strengths of these hubs were seen largely in relation to AI research versus commercialization, the majority of interviewees were aware of critical developments taking place in Toronto, Montreal, and Edmonton. The Vector Institute (in Toronto), Mila (in Montreal), and Amii (in Edmonton) were identified as essential bodies helping to support the growth of their regional hubs while attracting researchers and FDI. Many interviewees were aware of the presence of international transplants like Google, Facebook, IBM, and others in these locations. A few “up and coming” AI hubs were also identified, the most prominent being in Vancouver and Ottawa.

Leadership on Ethical AI

Despite growing pains of slow or unclear regulation alongside scale up challenges, interviewees highlighted that consultations and standardization efforts that have taken place in Canada on AI are prudent. Specifically, it was noted that Canada’s strategy for AI regulation was evidence-based—if slow. Many interviewees highlighted that Canada’s approach is expressly different (and more responsible) than the “hands off” approach taken in the US. Many interviewees felt that Canada had the potential to show leadership in responsible AI policy and regulation, alongside commercialization of AI products grounded in these norms.

The above and other factors contribute to an overwhelmingly positive view of Canadian AI research, development, and investment opportunities. However, interviewees highlighted some barriers that, although not pressing in the short term, Canada needs to address in the long-term.

Scale Up Issues Exist—Canada Has Good Research, but Commercialization Needs a Boost

While access to skilled talent was regarded as a pull factor for AI-based FDI to Canada, the relatively small portion of local AI success stories was highlighted by interviewees as an area of future concern. Although AI research is strong in Canada, interviewees noted a lack of awareness of any significant Canadian companies in the AI space. A few interviewees had some knowledge of Element AI—the only Canadian company to find its way to the 2019 CBI Insights ranking for 100 top AI companies in the world—but the majority highlighted at least some level of concern about the dearth of ‘big AI’ companies in Canada. When compared to competing jurisdictions like the US, China, and Europe, Canada comes up short on commercialization and scaleup. The presence of homegrown success stories, while less critical than access to talent and regulatory clarity, was regarded by some as relevant for FDI.

Talent Retention Worries

Although interviewees lauded Canada for its development of AI-skilled graduates and ability to source internationally trained AI talent, some also worried about retention issues, largely due to the proximity to the US. With easy access to top tech hubs in the US such as New York, Boston, Seattle, and the Silicon Valley—both geographically and via streamlined visa processes like the L-1 and TN—interviewees raised some concern about talent drain. Specifically, there was a worry that higher wages and access to big tech companies in the US, coupled with the high cost of living in cities like Toronto and Vancouver. Combined, these may present talent retention challenges for investors who set up operations in Canada.

Slow Movement in Regulation a Challenge

Although Canada has made some movement in the space of AI norms and standards development, ultimately, nearly 65% of interviewees who identified barriers for FDI attraction to Canada stated a concern about “unclear” regulations. Several interviewees felt that regulation around AI development and data use was “unclear” and “not well understood” in Canada. Many presumed that Canada was somewhere in between the US and the European Union on the matter but stated some apprehension around the lack of any official regulation or firm stance. This was coupled with challenges that some interviewees expressed around navigating different policies and legislation across provinces.

While this was not expressed as an immediate barrier, some felt that unclear regulation would deter investment in the long run. If businesses are not clear on how regulation will affect their activities in Canada, they may seek other options.

The Office of the Privacy Commissioner is currently investigating legislative reforms for the *Personal Information Protection and Electronic Documents Act (PIPEDA)* and the *Privacy Act*. In February 2020, a consultation on appropriate regulation on artificial intelligence was launched. To aid this review, the OPC has created a list of 11 proposals for PIPEDA amendment, many having parallels to the EU's *General Data Protection Regulation (GDPR)*.

CONCLUSION

AI is a transformative technology that can usher in substantial impacts across all sectors of the economy. In Canada and around the world, businesses are using AI to respond to a wide range of business needs. These include improving internal processes and generating efficiencies, enhancing customer experience, and developing new product lines or services, or managing risks. Industry experts interviewed in this study represented a total of eight countries and seven different sectors. Despite differences in use or implementation, the impact and value of AI was asserted and stressed by all.

Irrespective of time spent using or investing in AI, all interviewees asserted that it will be highly valuable in the near and long-term future; the vast majority were optimistic and eager to continue and expand their investments in AI. However, at the organizational level, a few barriers existed. These include a lack of organizational expertise in relevant areas, some reluctance to try “risky” technologies,” as well as challenges navigating regulatory requirements, both locally and internationally.

When it came to awareness of AI developments in Canada, nearly all interviewees relayed knowledge of key advancements like the Scale AI initiative, as well as the main hubs of Montreal, Toronto and Edmonton. Tied to these hubs, many interviewees also praised the skilled talent that came out of institutions such as University of Toronto, McGill, and the University of Alberta while noting that Canada is viewed as an attractive place for international talent. Combined, these features made Canada a highly attractive destination for AI investment; many interviewees expressed a sentiment that Canada is an “excellent place” for investment in AI. Concerns included apprehension about competition for talent, the small size of the local ecosystem, and Canada’s slow pace in AI regulation. The majority of interviewees did not view these challenges as prohibitive to any near-term investment in Canada’s AI ecosystem.

Canada enjoys a robust base of AI talent, a broad range of AI researchers exploring timely use cases, and a welcoming and effective immigration system that prioritizes the attraction of highly skilled international talent. These factors, when combined with innovative solutions to current-day societal challenges alongside growing global leadership in spaces like ethical AI, make Canada an attractive destination for AI investment.



APPENDICES

Research Methodology

This study includes the integration of both primary and secondary research. The primary research completed was of a qualitative nature, while secondary research largely relied on quantitative data extracted from various existing data sets, alongside an analysis of literature from both national and international sources.

Primary Research

ICTC conducted a total of 20 key informant interviews (KIIs) with a globally diverse group of industry representatives. Interviews were sourced through targeted outreach and were conducted between January and April 2020. Interviewees were all knowledgeable in AI and usually came equipped with other important pieces of understanding related to business needs, investment opportunities, challenges, etc. Organizations spanned seven sectors, eight countries, and were mostly from businesses generating high annual revenue streams (nearly 50% of companies with annual revenues of \$1B or more).

Interviews lasted approximately one hour each. Interviewees addressed topics related to their company's business and general economic outlook, AI needs and use cases, perceived barriers, as well as questions specifically tied to Canada and investment opportunities. These questions sought to understand knowledge levels of Canada's successes in AI, perceptions of Canada as a potential location for international business development and/or investment, advantages, barriers and more.

Interviews were carefully selected to align with the seven sectors of interest, with the following distributions: Advanced Manufacturing (2), Agriculture & Ocean Technology (3), Business & Finance (2), Digital Technology (6), Life Sciences (1), Natural Resources (3), and Transportation & Logistics (3).

Respecting the privacy of interviewees, all insights collected from interviews in this study are displayed in aggregate only. Any quotes used as examples of findings have been anonymized, with personal identifiers removed.

Secondary Research

The secondary research component of this study included a thorough literature review of existing reports and other documentation from both Canada and abroad. Data included for analysis was sourced from databases including but not limited to the OECD, the World Bank, Statistics Canada and Trading Economics. Lastly, because of the volatile nature of emerging technologies, as well as current economic realities brought on by COVID-19, recent events and relevant news has also been taken into account, where appropriate.

Limitations of Research

The information gathered via interviews in this study is sourced from key international industry experts, all of whom are highly knowledgeable in AI. Key informant interviews are a unique method to gather in-depth information and insights that are not available through existing data.

However, although key informant interviews are suitable for sourcing insights from industry leaders, the data obtained through these methods are always qualitative. That is, they should be expressed as interesting insights and feedback, not as any kind of benchmark meant to relay future growth or concrete opportunities. Moreover, because this research is based on a total of 20 interviews across industry lines and from various countries, ICTC emphasizes that they are not sufficient to provide an overall representation of AI needs, opportunities or threats. Once again, these are to be viewed and understood as relevant insights, not objective trends. ICTC also attempted to obtain interviews from Chinese AI businesses because of China's global market presence in AI, but unfortunately was not able to source any candidates willing to participate. Because of the highly proprietary and competitive nature of AI developments—in comparison to say 5G or blockchain, which frequently leverage existing platforms—several candidates for interviews expressed concern about questions that would be asked. Several stated that they would not be able to participate or provide any information regarding their AI practices due to strict IP protection policies.

Lastly, the advent of the COVID-19 global health pandemic will undoubtedly have colossal impacts on the global economy, including emerging technologies like AI. Further research conducted over a longer period of time is required to fully understand these impacts and their implications for commercialization, scale up, and investment.

SWOT Analysis: A Profile of Canada for AI Investment

Although often completed for specific businesses or products, the below provides an analysis of Canada's strengths, weaknesses, opportunities and threats (SWOT) in relation its the ability to attract AI-based investment. Rooted in a combination of secondary research and insights gained from interviews with potential investors, this is intended to showcase areas of success, existing struggles, potential roadblocks, and future opportunities for Canada on its AI investment-attraction journey.

Strengths

Strong Educational Institutions Producing Talent Supply and Research Capacity

As expressed by most interviewees in this study, Canada's education system and talent supply in the field of AI are well-regarded and respected. On the whole, Canada's overall education system was ranked third out of 80 countries, according the recent US News & World Report (using 75 evaluation metrics).¹⁵⁷ According to

¹⁵⁷ "Canada ranked 3rd best country in the world for education", Daily Hive, January 23, 2019,

the most QS Top University Rankings, six Canadian universities placed in the top 100 worldwide for computer science: the University of Toronto (10), the University of Waterloo (24), the University of British Columbia (25), McGill University (50–100), Université de Montréal (50–100) and the University of Alberta (50–100).¹⁵⁸

In the area of AI research, Canada boasts some of the world's top researchers, including Geoffrey Hinton and Yoshua Bengio. Bengio, a professor at the University of Montreal, was a co-recipient of the 2018 Turing Award for his work in deep learning.¹⁵⁹ Since 2017, Bengio has founded Mila (the Montreal Institute for Learning Algorithms), a research institute for machine learning that has quickly become one of the premier centres for AI research in the world.¹⁶⁰ With the intent of turning Canada as whole into a global leader in AI, the world's first national AI strategy was developed in Canada in 2017.¹⁶¹ Backed by \$125 million in investment, the strategy focuses on growing the ranks of AI researchers in the country by supporting the production and attraction of skilled researchers and practitioners in Canada.

On the AI education front, schools such as the University of Toronto, the University of Alberta, and McGill University were well-known by nearly all interviewees as top institutions producing highly skilled AI talent. AI graduates from these institutions are highly sought-after by AI startups and large corporations, alike—both in Canada and abroad. The University of Alberta notes that former graduates are currently employed with leading organizations like DeepMind, IBM, and Microsoft.

Robust Support Networks: Government and Industry

Many recent developments highlight Canada's commitment to technology, including AI, as a driver of economic growth in the country. Part of the Innovation Superclusters initiative, located in Montreal, Scale AI received over \$250 million in government funding to boost Canada's strength in the AI space, with a focus on integrating the technology into supply chains and sharing knowledge across sectors. The Scale AI cluster is comprised of private industry, academic institutions, professional associations, government partners, venture capital firms, and global partners.¹⁶² To date, Scale AI has funded 10 key projects. Partners include Air Canada, Stream Systems, Plotly, and AlayaCare.¹⁶³

Although the Scale AI supercluster is based in Quebec, AI support systems like research institutes, foundations, incubators, and venture capital firms are located across Canada. The three main Canadian AI hubs (Montreal, Toronto and Edmonton) are home to over 800 staff, students, and researchers. This includes the Alberta

<https://dailyhive.com/vancouver/canada-ranked-best-country-education-2019>.

¹⁵⁸ "QS World University Rankings 2020: Computer Science & Information Systems", <https://www.topuniversities.com/university-rankings/university-subject-rankings/2020/computer-science-information-systems>

¹⁵⁹ Jeremy Kahn, "Three 'Godfathers of Deep Learning' Selected for Turing Award", Bloomberg, March 27, 2019, <https://www.bloomberg.com/news/articles/2019-03-27/three-godfathers-of-deep-learning-selected-for-turing-award>.

¹⁶⁰ "Massive new centre for AI research opens in Montreal", Global News, January 28, 2019, <https://globalnews.ca/news/4899040/massive-new-centre-for-ai-research-opens-in-montreal/>.

¹⁶¹ "Canada first to adopt strategy for artificial intelligence", UNESCO, November 22, 2018, http://www.unesco.org/new/en/media-services/single-view/news/canada_first_to_adopt_strategy_for_artificial_intelligence/.

¹⁶² "Our Members", scale ai, <https://scaleai.ca/members/>.

¹⁶³ "Investments of \$75 million: Scale AI propels 10 AI projects", Scale AI, January 14, 2020, <https://scaleai.ca/wp-content/uploads/2017/11/ScaleAI-Announce-invest-2020-01-Communiquee%CC%8C-v09final-EN.pdf>.

Machine Learning Institute (Amii) (120), Mila (450), and the Vector Institute (240). Each of these three institutions have received significant investment to support and grow AI research and development in Canada. Other notable developments include the creation of Element AI, an AI development and consultancy that was recently named one of the top 100 AI companies in the world by CB Insights.

Historically Stable Economy and High Standard of Living

While not expressly linked to AI investment, Canada benefits from well-connected a stable economy coupled with a high standard of living. With quality of life being a key consideration for international companies who send international transfers or expats abroad when opening or expanding a business, Canada is rated 13th in the world, according to the United Nations' Human Development Index. Five Canadian cities place in the top 100 in Mercer's 2019 Quality of Living Ranking. The UN's Human Development Index combines indicators on life expectancy, education quality, and per capita GDP; Mercer's Quality of Living Ranking factors in variables like climate, ease of communication, political stability, and mobility.

On the economic front, Canada's economy was the 10th largest in the world in 2019, with total gross per capita median income ranked seventh globally. Last December, the Canadian economy was projected to be the second-fastest growing G7 economy in 2020. Currently, global economic activity is projected to land at approximately 0.4%.¹⁶⁴ Although COVID-19 impacts all economies in significant ways, Canada's history of relatively conservative economic governance (compared to the United States) may prove valuable in weathering this storm. While the 2008 recession and the current COVID-19 pandemic differ in numerous ways, Canada was the first G7 country to recoup its losses from the 2008 recession.

Weaknesses

Small AI Ecosystem and Lack of Globally Known Industry Trailblazers

Although the Canadian tech ecosystem has seen substantial growth over the last few years,¹⁶⁵ Canada remains a small country relative to the US, both in terms of overall economic footprint and the presence of large firms. In 2019, Canada's largest tech company, CGI, earned roughly \$20 billion CAD in revenue.¹⁶⁶ During the same time period, Apple, the largest tech company in the US, earned over 1000% more.¹⁶⁷ There are numerous large technology companies in the US such as Amazon, Microsoft, IBM, Twitter, Salesforce, etc. Canada has proved far less effective at producing tech unicorns. To date, Canada has produced only two unicorns, while the US has produced over 120.¹⁶⁸ On the AI front specifically, eight Canadian companies were highlighted in the list of top 100 AI startups in the world in 2020, according to CB Insights.

¹⁶⁴ "Economic Research: The Escalating Coronavirus Shock is Pushing 2020 Global Growth Toward Zero", S&P Global Ratings, March 30, 2020, <https://www.spglobal.com/ratings/en/research/articles/200330-economic-research-the-escalating-coronavirus-shock-is-pushing-2020-global-growth-toward-zero-11413969>.

¹⁶⁵ OMERS Ventures, "Canadian Tech Ecosystem in the Past 20 Years. A Closer Look into Deloitte's Technology Fast 50 Program Trends", Medium, December 19, 2017, <https://medium.com/omers-ventures/canadian-tech-ecosystem-in-the-past-20-years-268d008b07e8>.

¹⁶⁶ "CGI reports strong Q4 and Fiscal 2019 results", CGI, <https://www.cgi.com/en/2019-11-06-CGI-reports-strong-Q4-and-Fiscal-2019-results>.

¹⁶⁷ "Apple Revenue 2006-2019", Macrotrends, <https://www.macrotrends.net/stocks/charts/AAPL/apple/revenue>.

¹⁶⁸ "The Global Unicorn Club", CB Insights, 2020, <https://www.cbinsights.com/research-unicorn-companies>.

While Canada has a solid startup ecosystem, Canadian tech companies face challenges in growing. In the 2019 Ecosystem Ranking Report, several Canadian cities saw drops in their scores; Toronto dropped four spots to #15, Vancouver dropped six places to #24 and Montreal saw the steepest decline, dropping 15 paces to #49.¹⁶⁹ Compared to the US, startups in Canada struggle to grow, with significant challenges that include accessing industry investment and fragmented government support. A recent study by the University of Toronto's Impact Centre found that venture capital funding was especially scarce from Canadian investors. It uncovered that Canadian startups tended to have twice as many investments from foreign VCs than Canadian ones. Investments from Canadian VCs tended also to be much smaller; the 30% of companies without any Canadian investors received nearly three times more money than companies who had Canadian investors only.¹⁷⁰ On fragmentation of support, Canada has different regulation, tax incentives, and support systems, with much of these dependent on provincial or city initiatives. As a result, the size and growth of heavily supported ecosystems like Toronto, Montreal, or Vancouver differ dramatically from others.

Talent Retention Challenges

FDI in Canada has shown growth over the years, with notable international transplants calling Canada home. Global tech giants like Google, Facebook, Amazon, Microsoft, and Sony Imageworks have all opened up Canadian headquarters (as well as smaller tech leaders like SurveyMonkey and MailChimp). FDI contributes substantially to the growth of the Canadian tech sector and is undoubtedly responsible for significant job creation, innovation, and even further investment attraction. However, the presence of large US companies in Canada—and the proximity to major US tech hubs like Seattle and Silicon Valley—are not without their challenges.

Large companies, with the potential to offer salaries far above local market rates, have the advantage of attracting top Canadian talent in the AI space. This challenge was highlighted by industry leaders in this study, both by large multinationals with offices in several countries around the world and smaller ones with operations in Canada. Here, the “brain drain” challenge is two-fold: first, struggling to retain talent in the face of global tech giants *within* Canada, followed by proximity to global tech hubs like Silicon Valley that attracts Canadian talent.

While Canada is relatively successful in attracting talent from abroad, retaining its own talent is often a struggle for reasons including the small ecosystem and wage competition. A recent study by the Munk School of Global Affairs found that roughly one in four STEM graduates from institutions like the University of Waterloo, the University of Toronto and the University of British Columbia were working outside of Canada in 2018. For computer science graduates, this figure was even higher, where two out of three grads were internationally based (mostly in the US).¹⁷¹

¹⁶⁹ Isabelle Kirkwood, “Canada’s Tech Hubs Fall in Startup Ecosystem Rankings, Smaller Cities Show Promise”, Betakit, April 23, 2019, <https://betakit.com/canadas-tech-hubs-fall-in-startup-ecosystem-rankings-smaller-cities-show-promise/>.

¹⁷⁰ Pragya Sehgal, “Canadian venture capital sufficiency study: Key takeaways”, IT World Canada, October 15, 2019, <https://www.itworldcanada.com/article/canadian-venture-capital-sufficiency-study-key-takeaways/422700>.

¹⁷¹ Zachary Spicer et al., “Reversing the Brain Drain: Where is Canadian STEM Talent Going?”, Brock University et al.,

Unclear AI Regulation

Many interviewees in this study highlighted that while Canada has developed draft strategies for AI regulation or policy, actual regulation around data collection and use of AI in Canada has been slow, with existing norms being unclear or difficult to navigate. Many interviewees said that this lack of clarity can eventually present notable challenges for investment. In the absence of clear standards and protocols, potential investors in the AI space are left with a fuzzy picture of how their business would operate in the country.

Several interviewees praised Canada's more cautious approach to AI development and deployment, in comparison to the US. In Canada, it is not uncommon for academic institutions like the Vector Institute or Mila to work closely with industry, venture capitalists and government¹⁷²; in a way, this helps Canada create a better and more cohesive overall strategy around AI. Overall, this kind of collaboration was seen as a very positive feature; where Canada fares less well is around actual guidelines and regulation for the use of AI.

Over the last year, several regulatory proposals have been put forth by leading AI hubs around the world. Likely drawing little surprise, AI regulation in the US came out relatively thin, taking a general "hands off" approach¹⁷³ to minimize government interference. In the EU—arguably the established global leader in regulation around data protection and artificial intelligence—the GDPR (General Data Protection Regulation) already contains measures of legal clarity on topics like AI. This baseline was further enhanced with the recent much-anticipated white paper on AI by the European Commission.¹⁷⁴ A key takeaway from this white paper: the EU commits to placing stricter regulations on technologies that have fundamentally present risks to human rights—this includes facial recognition, a thorny topic for many EU member states, including Germany and France, which are already planning to roll out the technology in public spaces like train stations and airports.¹⁷⁵ Referred to by some as a "double-sided approach,"¹⁷⁶ the EU aims to implement AI, but only insofar as it is not harmful to EU citizens.

Many speculate that Canada will eventually land somewhere in between the US and the EU, but movement on this front has been slow and relatively uneventful to date. This lack of action or clarity may become problematic. Echoed by interviewees in this study, other industry experts like Mahdi Amri, Deloitte's AI lead, highlight that the lack of a legal framework can have the consequence of undermining trust and accountability,¹⁷⁷ which could negatively impact Canada's AI journey.

<https://brocku.ca/social-sciences/political-science/wp-content/uploads/sites/153/Reversing-the-Brain-Drain.pdf>.

¹⁷² Tom Davenport, "Learning From the Canadian AI Model", *Forbes*, November 19, 2019,

<https://www.forbes.com/sites/tomdavenport/2019/11/19/learning-from-the-canadian-model-of-ai/#3dd496552300>.

¹⁷³ James Vincent, "White House encourages hands-off approach to AI regulation", *The Verge*, January 7, 2019,

<https://www.theverge.com/2020/1/7/21054653/america-us-ai-regulation-principles-federal-agencies-ostp-principles>.

¹⁷⁴ "White Paper On Artificial Intelligence – A European approach to excellence and trust", *European Commission*, February 19, 2020,

https://ec.europa.eu/info/sites/info/files/commission-white-paper-artificial-intelligence-feb2020_en.pdf.

¹⁷⁵ Samuel Stolton, "EU police plan massive facial recognition database", *EurActiv*, February 23, 2020,

<https://www.euractiv.com/section/digital/news/eu-police-plan-massive-facial-recognition-database/>.

¹⁷⁶ Sílvia Amaro, "EU launches plan to regulate AI, taking aim at Silicon Valley giants", *CNBC*, February 19, 2020,

<https://www.cnbc.com/2020/02/19/eu-launches-plan-to-regulate-ai-aimed-at-silicon-valley-giants.html>.

¹⁷⁷ Chris Reynolds, "Canada lacks laws to tackle problems posed by artificial intelligence: Experts", *Global News*, May 19, 2019,

Opportunities

Growing AI Research Hubs

Home to thought leaders including Yoshua Bengio and Geoffrey Hinton, Canada is becoming a well-known and respected global hub for AI research. Since the early 1980s, Canadian Institute for Advanced Research (CIFAR) has supported researchers to explore numerous AI fields, including machine learning, neural networks, deep learning and reinforcement learning.¹⁷⁸

In 2017, CIFAR kicked off its \$125 million Pan-Canadian AI Strategy. A global first, the purpose of the strategy is to increase the presence of AI researchers in Canada, establish centres of AI excellence across the country and develop Canadian-grown global thought leadership on the economic, ethical, policy and legal implications of AI.¹⁷⁹ Over the years, the number of CIFAR AI Chairs has steadily increased, with approximately 80 now located across Toronto, Montreal, and Edmonton. CIFAR AI Chairs commit to researching various areas of interest, including healthcare autonomous vehicles.¹⁸⁰ Other CIFAR-related advancements include the establishment of Amii, Mila and the Vector Institute; the launch of the AI & Society program investigating critical topics like the role of AI in healthcare, climate change and its impact on vulnerable populations¹⁸¹; and the launch of the AI4Good Lab, a two-month training program teaching AI applications as a force of social good.

Growing Attractiveness for Internationally Skilled Workers and Academics

Two world-renowned AI leaders—Yoshua Bengio and Geoffrey Hinton—call Canada home. With key advancements made in AI research, coupled with a welcoming and effective immigration system, Canada has the potential to attract internationally educated talent and researchers the field of AI.

This attractiveness for international skilled talent was mentioned by interviewees in this study as a key feature. The reasons for this are two-fold. First, a country that can attract skilled talent with relative ease reassures investors about the ability to build the workforce they need to support business growth in a new location; at the same time, access to skilled international talent is also critical to a growing and strong local ecosystem.

The skills-first focus of the Canadian immigration system is also key in attracting in-demand internationally trained workers. In recent years, Canada has seen an increase of international talent, outstripping that of the US. While the US began clamping down on immigration in early 2017, Canada launched an innovative program to attract skilled foreign workers. Approximately three years ago, the Global Skills Strategy launched, leading to the creation of a fast-track visa process—the Global Talent Stream—that processes work permits for skilled workers fitting

<https://globalnews.ca/news/5293400/canada-ai-laws/>.

¹⁷⁸ Ryan McLaughlin et al., "On the Edge of Tomorrow: Canada's AI Augmented Workforce", ICTC, February 2020, <https://www.ictc-ctic.ca/wp-content/uploads/2020/02/canadas-ai-workforce-FINAL-ENG-2.24.20.pdf>.

¹⁷⁹ "CIFAR Pan-Canadian Artificial Intelligence Strategy", CIFAR, <https://www.cifar.ca/ai/pan-canadian-artificial-intelligence-strategy>.

¹⁸⁰ "The Canada CIFAR AI Chairs", CIFAR, <https://www.cifar.ca/ai/pan-canadian-artificial-intelligence-strategy/the-canada-cifar-ai-chairs>.

¹⁸¹ "AI & Society", CIFAR, <https://www.cifar.ca/ai/ai-society>.

certain profiles (including computer science-based roles), in as little as two weeks.¹⁸² Viewed as a resounding success, over 24,000 highly skilled workers have entered the Canadian workforce since the launch of the program.

Growth in Innovative Educational Programs

Canada is home to a rich and growing variety of recognized educational programs related to AI. This includes programs in AI, machine learning, cognitive neuroscience, and other areas. These programs are available at bachelors, master’s, and doctorate levels.

While these programs are growing and expanding on a regular basis, Table 3 provides examples of existing recognized AI educational programs offered in Canada.

Table 3. Examples of notable AI-related programs in Canada.

INSTITUTION	DEGREE	PROGRAM
University of Toronto	Bachelor of Science	Computer Science—Artificial Intelligence
University of British Columbia	Bachelor of Science	Cognitive Systems
University of Windsor	Bachelor of Computer Science	Artificial Intelligence
Dalhousie University	Bachelor of Computer Science	Artificial Intelligence and Intelligent Systems
Simon Fraser University	Master of Science	Computer Science - Artificial Intelligence
University of Guelph	Master of Science	Artificial Intelligence
University of Alberta	Master of Science	Behaviour, Systems and Cognitive Neuroscience
University of Alberta	Master of Science	Artificial Intelligence
University of Waterloo	Doctor of Philosophy	Artificial Intelligence
University of Alberta	Doctor of Philosophy	Behaviour, Systems and Cognitive Neuroscience
University of Manitoba	Doctor of Philosophy	Artificial Intelligence
Lakehead University	Master of Science	Computer Science – Artificial Intelligence
Ontario Tech University	Master of IT Security	Artificial Intelligence Security
University of Ottawa	Master of Computer Science	Applied Artificial Intelligence
University of Waterloo	Master of Data Science and Artificial Intelligence	Data Science and Artificial Intelligence
Universite de Montreal	Master of Computer Science	Artificial Intelligence
University of Laval	Master of Computer Science	Artificial Intelligence
McGill University	Master of Science	Computer Science – Artificial Intelligence

Opportunities for Leadership in Ethical AI

Although still in early phases, Canada has the potential to excel and show global leadership in the space of ethical AI. Several interviewees in this study regarded Canada’s approach to AI as being more measured than that of the US. Relatedly, a global survey of over 300 business leaders identified that, despite the slow pace of actual regulation, developments led by CIFAR is establishing Canada as a global leader in ethical AI.¹⁸³

¹⁸² “Global Skills Strategy launched 2 years ago, results in hiring 24,000 foreign workers”, *CanadIM*, June 19, 2019, <https://www.canadim.com/blog/global-skills-strategy-hires-24000-foreign-workers/>.

¹⁸³ “Organizations Are Gearing Up for More Ethical and Responsible Use of Artificial Intelligence, Finds Study”, *Accenture*, September 25, 2018, <https://www.accenture.com/ca-en/company-news-release-artificial-intelligence-finds-study>.

The push toward leadership in this space expand beyond CIFAR as well. Recently, the Treasury Board Secretariat finalized its guidelines on the appropriate use of AI in government. Considering that “smart,” or connected, government and citizen services are likely to emerge as technology growth accelerates, setting clear guidelines for what is or is not appropriate is key. Overall, the guidelines highlight that any use of AI in government must meet the following criteria: be understandable and measurable, be transparent, be explainable, and be open.¹⁸⁴ The guidelines also suggest that training must be made available for public service employees to use and adopt it.¹⁸⁵ Other examples include the Montreal Declaration for a Responsible Development of AI focusing on developing an ethical framework for AI in Canada¹⁸⁶ and the recent decision by Waterfront Toronto to have Element AI study the human rights implications of the Sidewalk Labs project (when the project was still in existence).¹⁸⁷

Threats

High Household Debt

According to the Governor for the Bank of Canada, household debt levels are the economy’s biggest vulnerability.¹⁸⁸ Part of the reasons for high levels of household debt in Canada is the drastic increase seen in house prices across many Canadian jurisdictions in recent years. While the 2008 recession decimated the US housing market, it had little effect in Canada. Between 2008 and 2009, home prices in Canada fell by just 7% before they began rising again. Since 2009, Canada’s real home prices rose 54% to the present day. Canada’s home prices barely dipped as a result of the Global Financial Crisis, and then continued to increase rapidly. Canada’s inflation-adjusted home prices have risen more rapidly than any other developed country since 2005. In less than 15 years, in inflation-adjusted terms, homes in Canada have nearly doubled in price.

The high cost of living in many of Canada’s top cities for tech talent like Toronto or Vancouver were noted by interviewees in this study. As one interviewee from the life sciences sector with operations in Vancouver put it,

The cost of living is a barrier to scaling our company. It's expensive to live here. Especially when we try to bring [US hires] up, they look at how much they could make in Palo Alto and decide not to come... We're not bringing in much US talent. It's challenging with the economics.

¹⁸⁴ “Responsible use of artificial intelligence (AI)”, Government of Canada, <https://www.canada.ca/en/government/system/digital-government/modern-emerging-technologies/responsible-use-ai.html#toc1>.

¹⁸⁵ *Ibid.*

¹⁸⁶ “The Montreal Declaration for responsible AI”, <https://www.montrealdeclaration-responsibleai.com/the-declaration>.

¹⁸⁷ James McLeod, “Element AI tapped to study human rights implications of Sidewalk Labs plan”, *Financial Post*, January 16, 2020, <https://business.financialpost.com/technology/element-ai-tapped-to-study-human-rights-implications-of-sidewalk-labs-plan>.

¹⁸⁸ Erik Hertzberg, “Canadians’ mountain of household debt rising again”, *Financial Post*, December 13, 2019, <https://business.financialpost.com/personal-finance/debt/canada-q3-household-debt-to-income-ratio-rises>.