PAN-CANADIAN AI STRATEGY IMPACT ASSESSMENT REPORT

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1.0 EXECUTIVE SUMMARY

In 2017, the Government of Canada appointed CIFAR to develop and lead the Pan-Canadian Artificial Intelligence (AI) Strategy. Worth $125 million, it is the world's first national AI strategy. Thanks to the Strategy, AI centres across Canada have evolved into a coordinated and flourishing ecosystem. The ecosystem serves to translate AI research discoveries into applications for use in both the public and private sectors. The strategy is beneficial to the development of the AI ecosystem in Canada and was launched at the right time to generate momentum. As countries around the world invest in the growth of their own ecosystems, it's important for Canada to continue its support in the next evolution of the strategy. Progress in AI via the strategy enriches many areas of the country. For example, it creates economic benefits through the commercialization and adoption of AI. It drives advances in knowledge and R&D. The strategy generates job creation. It attracts new talent and develops talent through education. And it improves society by promoting AI for Good and Responsible AI initiatives. The strategy's impact on these domains and Canadian regions is assessed below.

Commercialization and adoption of AI: Canada saw 50 percent growth in foreign direct investment in information and communication technologies (ICT) from 2017 to 2019. Over 45 companies have invested in Canadian AI research labs since 2017. This includes Microsoft, which expanded its lab to 75+ employees. Google DeepMind, which chose Edmonton as its first international location. And Thomson Reuters invested $100M in a new technology centre. As the presence of large technology companies has increased, the AI startup ecosystem has thrived. In 2019, Canadian AI startups received over $600 million in funding. This is an increase of 2.3x since 2017. CIFAR and its associated AI institutes, Amii, Mila and the Vector Institute, help enterprises across Canada commercialize AI applications. The International Data Corporation (IDC) projects more Canadian companies will adopt AI. It predicts AI technology spend will grow at a CAGR of 25 percent.

Research & development: Eighty leading researchers have been retained in and recruited to Canada through the CIFAR AI Chairs program. In 2019, two Canadians, Yoshua Bengio and Geoffrey Hinton (along with their colleague Yann LeCun) won the Turing Award, widely considered the "Nobel Prize of Computing". Canada is ranked 4th globally in H-Index. The University of Alberta, Université de Montréal, and the University of Toronto are cited as top schools for research in artificial intelligence.

Talent and job creation: The strategy's brand attracts and retains a highly skilled talent pool. This resulted in a job-creating ecosystem in Canada. Between 2018 and 2019, employment in technology occupations grew by 3.6 percent. During the same time, growth in employment across all occupations was approx. 1.7 percent. From 2016 to 2019, Canada increased its AI Skills Migration Index rank. This measures talent inflow and outflow among 55 countries. During this period, Canada moved up 20 spots to reach 4th place.

Education: Canada achieved a 26 percent growth in math, computer and information science enrolment since 2015/16, compared to 3 percent growth in all other postsecondary enrolment.

Social: CIFAR, Amii, Mila and the Vector Institute prioritize the progression of AI for Good across societal causes such as health, education and the environment. This is achieved through a portfolio of innovative programs. Canada has consistently ranked in the top 5 for number of AI publications on social and welfare topics, publishing over 500 publications since 2017.

Responsible AI: Canada and France founded the Global Partnership on AI (GPAI). It has a strong focus on responsible AI. **Mila with UdeM lead UNESCO's online consultation on AI ethics.** The goal is to construct the first global normative instrument by building on the Montreal Declaration for Responsible AI. Canada continues to review its existing regulatory requirements. And the country is reforming the Personal Information Protection and Electronic Documents Act (PIPEDA).

Regional Impact Evaluation: The establishment of three AI institutes, Amii, Mila, and the Vector Institute, created a network of collaboration across the country. This has enabled regions to deepen their strengths in specialized fields while maintaining cross-regional synergies. The result is an ecosystem that is greater than the sum of its parts.

- **Alberta:** Alberta offers world-class research in reinforcement learning. From 2017 to 2019, the province tripled the number of reinforcement learning papers. The University of Alberta is ranked as the top Canadian institute in the world for AI and ML research output on CSRankings (1998 to 2019). Amii and the AI strategy helped develop an AI network centred around this research. The network has led to the expansion of the technology sector and computer science education in the province.
- **Ontario:** Ontario and the Vector Institute have contributed heavily to industry research collaborations and the commercialization of AI. The provincial government and private sector invested a further $100+ million on top of the strategy. In 2019, Toronto was named the fastest growing city for technology jobs in North America by CBRE.
- **Quebec:** Quebec benefits from a province-wide collaborative ecosystem, aided by an additional $100 million in provincial funding. This has allowed the province to progress its world-renowned deep learning and machine learning research.
- **British Columbia:** British Columbia has a flourishing high-technology industry. This enables the province to embed its AI ecosystem in diverse technology applications. In 2019, Vancouver saw a growth of 43 percent in technology employment.

1.0 KEY IMPACTS OF THE PAN-CANADIAN AI STRATEGY

Since 2017, the Pan-Canadian AI Strategy has demonstrated significant economic and social impact. AI centres across Canada have evolved into a coordinated, flourishing ecosystem that serves to translate AI research discoveries into applications for the public and private sectors.

80 of the world's leading researchers

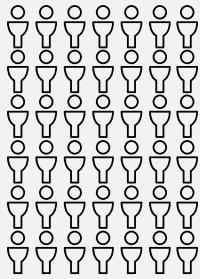retained and recruited to Canada through the Canada CIFAR AI Chairs program

2018 Turing Award Winners

Yoshua Bengio (UdeM & Mila)
Geoffrey Hinton (UofT & Vector Institute)

"The Nobel Prize of Computing"

1200+

Trainees supervised by Amii, Mila, and the Vector Institute

amii   **V** VECTOR INSTITUTE   Mila

50% growth

in ICT **foreign direct investment**

from 2017 to 2019 (based on total book values)

2.3x growth in funding

deployed to AI startups since 2017

45+ companies invested in AI research labs **in Canada**, including Microsoft, Google DeepMind, and Thomson Reuters

190 formal industry partnerships developed by CIFAR, Amii, Mila and the Vector Institute

Ranked #4 in 2019 AI Skills Migration

a measure of inflow and outflow of talent

Up 20 spots since 2015

Three Canadian universities in top 25 ML programs globally
per CSRankings

University of Toronto

University of Alberta

Université de Montréal

3.6% technology employment growth
vs. all occupation employment of 1.7%

3.6%

1.7%

2018 to 2019

26% growth in math, computer and information science enrolment
3% growth in all postsecondary enrolment

All Enrolment

Math, Computer and Information Science

2015-2017

KEY R&D LAB INVESTMENTS MADE IN 2017

Google Brain establishes first Canadian lab

Facebook launches AI research lab in Montreal

DeepMind chooses Edmonton as its first international lab

2.0 INTRODUCTION

Canada is home to some of the most renowned pioneers in AI and continues to invest meaningfully in this field. Artificial intelligence has the potential to transform how we live. And it will certainly be a key influence on both the social and economic lives of Canadians.

Recent technology advancements have correspondingly driven advances in AI. Innovations in distributed processing and storage via big data technologies enables artificial intelligence to read through enormous scales of data to make predictions. Modern cloud infrastructures allow organizations to adopt new AI technologies with lower entry barriers. And new advancements in reinforcement and deep learning research have supported new AI applications like natural language generation.

CIFAR has promoted high-quality foundational research since 1982. In 2017, CIFAR received $125 million of federal funding to support the Pan-Canadian AI Strategy. The goal is to reinforce both national and regional ecosystems and provide economic and social growth for Canadians.

CIFAR's Pan-Canadian AI Strategy aims to achieve the following :
1. Enhance Canada's international profile and visibility in artificial intelligence research and training.
2. Increase productivity in AI academic research and enhance capacity to generate world-class research and innovation.
3. Increase collaboration across institutes and strengthen relationships with receptors of innovation across sectors.
4. Attract and retain AI talent in Canadian universities and industry and AI research capabilities through a palette of training opportunities.
5. Translate AI research discoveries into applications for the public and private sectors leading to socio-economic benefits.

CIFAR works with partners (CIFAR's AI Chairs and the AI Institutes) to collaborate with other groups. These include academia, government, startups, and mature enterprises. The purpose is to ensure the goals of the strategy are realized.

Since its introduction in 2017, the Pan-Canadian AI Strategy has enjoyed success across multiple dimensions. However, there is still much work to be done. While other countries increasingly invest in both research and commercialization, Canada must continue to build on its strengths. Doing so will enable Canada to deliver further economic and social benefits to Canadian businesses and citizens. This report examines Canadian successes in this area and provides thoughts on the future.

3.1 COMMERCIALIZATION & PRIVATE SECTOR ADOPTION (1/3)

Since the strategy's launch in 2017, Canada has seen a significant increase in AI investment from companies around the world.
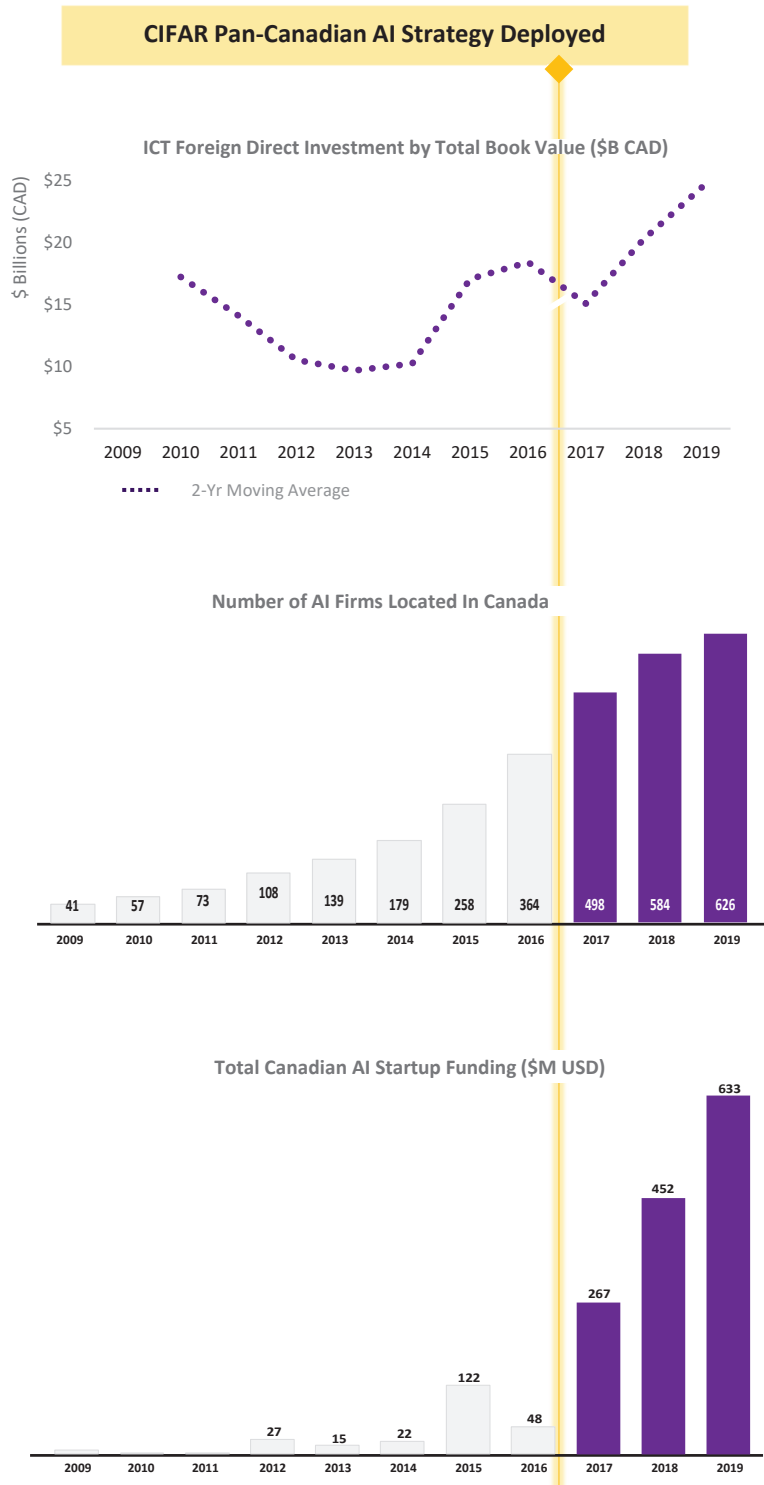
Since 2017, over 45 companies have invested in AI research labs in Canada. Microsoft hired over 75 employees for its Montreal research lab. Thomson Reuters invested $100 million in its Toronto Technology Centre. And DeepMind chose Edmonton for its first international location.[1]

These investments were part of a 50 percent growth in foreign direct investment in information and communication technologies from 2017 to 2019 (based on total book values).[2]

As the presence of large technology companies increased in Canada, the AI startup ecosystem grew significantly. CIFAR, Amii, Mila and the Vector Institute's investment in Canadian AI talent, when coupled with that of big tech firms, spurred innovation. Startups with innovative ideas for AI applications received the support they needed to succeed. Canada had 620+ active AI startups in 2019. This was 30 percent more than the German ecosystem at the same time. Over 240 of those startups received funding, and more than 50 startups received it past seed stage.[3] In 2019, total AI startup funding exceeded $600 million, up 2.3x since 2017. Notably, Ada and Clio, two successful Canadian startups, secured $60 million and $250 million in funding, respectively.[4,5] As of Q2 2020, AI startups have received close to $300 million in funding. This ecosystem has attracted and spawned some of the world's leading incubators and accelerators. For instance, TechStars chose Montreal as the base for its AI accelerator in 2018.[6] Similarly, NEXT Canada developed an AI-focused program in 2017.[7] The country is full of world-leading incubators and accelerators. They are working to help Canadian startups achieve success, e.g. the DMZ by Ryerson, Creative Destruction Lab, Alberta Innovation Corridor, Next AI and MT Lab.

The vibrant AI startup ecosystem is seeing success. It includes 34 AI startup acquisitions since 2017 and 11 IPOs in the past decade.[3] Canadian acquirers are leveraging these acquisitions to expand their AI capabilities internally.

From the foundation of CIFAR's Pan-Canadian AI Strategy emerged the Canadian AI ecosystem. The startups that spawn from this movement are essential in helping enterprise firms commercialize and scale AI use cases.

CIFAR Pan-Canadian AI Strategy Deployed

ICT Foreign Direct Investment by Total Book Value ($B CAD)

- - - 2-Yr Moving Average

Number of AI Firms Located In Canada

2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
41	57	73	108	139	179	258	364	498	584	626

Total Canadian AI Startup Funding ($M USD)

2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
			27	15	22	122	48	267	452	633

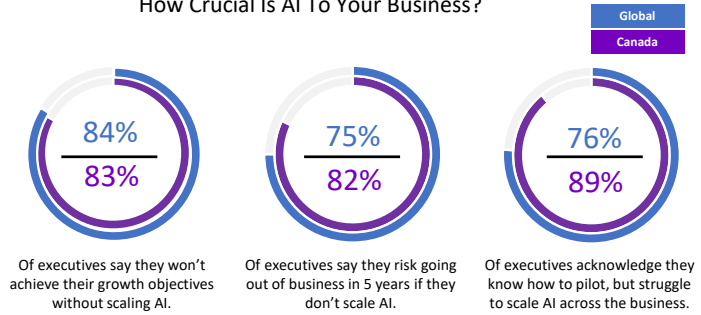# 3.1 COMMERCIALIZATION & PRIVATE SECTOR ADOPTION (2/3)

Investment in AI is essential for businesses to compete in the digital economy. Canadian executives understand the need for investment in AI. But they struggle to adopt it across the enterprise. The maturing Canadian AI ecosystem accelerates M&A activity. This supports enterprises of all sizes as they scale AI capabilities.

CIFAR, Amii, Mila and the Vector Institute play an integral role in supporting partnerships to scale AI. CIFAR and the institutes developed 177 formal partnerships with the private sector in 2018/2019. This is up from the 52 established in the year before.[1] Amii, Mila and the Vector Institute have supported 75+ startups in the past 3 years. This is over 12 percent of all AI startups active in 2020.

Canadian technology spend on AI is projected to grow at 25 percent (annually from 2018 to 2023).[2] This is above the projected 21 percent annual growth for the US. Firms are building AI capabilities through internal R&D labs, as well as acquisitions.

How Crucial Is AI To Your Business?

Global
Canada

84%
83%

Of executives say they won't achieve their growth objectives without scaling AI.

75%
82%

Of executives say they risk going out of business in 5 years if they don't scale AI.

76%
89%

Of executives acknowledge they know how to pilot, but struggle to scale AI across the business.

Source: Accenture Study: How Crucial is AI To Your Business?[3]

Canada's maturing AI startup ecosystem has seen increased acquisition in recent years. This activity grew at an annual rate of over 20 percent during the past 3 years.[4] As AI startups scale into enterprise-ready solutions, both large and small corporations have accelerated acquisition within the Canadian landscape.
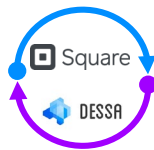
ELEMENT AI / **mldb.ai** — Element AI acquired open source machine learning database with the acquisition of mldb.ai.[5]

Square / **DESSA** — Square acquired machine learning and AI firm Dessa to bolster its product suite and maintain operations in Ontario.[7]

benkinney TEAM / **gabbi.ai SELL MORE HOMES** — Ben Kinney's acquisition of Gabbi.ai aimed to cut down daily tasks by 75% with artificial intelligence.[9]

TD / **layer6** — TD acquired AI firm Layer 6 to enhance personalized insight to improve the customer experience.[6]

Morgan Stanley / **Shareworks BY MORGAN STANLEY** — Morgan Stanley acquired Solium Capital (rebranded as Shareworks) a Calgary-based financial reporting SaaS firm.[8]

As part of the Government of Canada's innovation program, $950 million has been invested in five superclusters. These will drive technology and AI adoption.[10] The investment works hand-in-hand with the Pan-Canadian AI Strategy. The Scale AI Supercluster, one of the five superclusters, accelerates the integration of AI across all industries to enhance supply chains. Scale AI is partnering with over 110 organizations to build and apply AI solutions. They include CN, Air Canada, and the Ontario Farm Fresh.[11] The supercluster has invested in twenty transformational projects and counting since 2019. It has greatly helped scale large and small organizations along the way.[11]

Scale AI Supercluster Projects[12]

- **Modernizing home care for better client outcomes:** Helps home healthcare agencies prepare their workforce to meet the growing demands of Canada's aging population through an AI-informed software platform.

- **Farm to market:** Gives farmers access to new markets and reduced costs by using AI algorithms to identify co-loads and project ship dates.

- **Demand forecasting and real-time monitoring in retail businesses (FIND.AI):** Offers an industry-specific inventory and supply chain planning solution for apparel, footwear and accessories (AFA) retailers. The solution ensures improved predictability of product demand and control of production. This is even more important in an era when the retail industry is heavily impacted by the current pandemic.

3.1 COMMERCIALIZATION & PRIVATE SECTOR ADOPTION (3/3)

The AI institutes are actively engaged with companies to help them develop and adopt AI use cases, some of these examples are outlined below:

DrugBank, the worlds largest pharmaceutical knowledge base, launched in 2006. It has grown into an internationally recognized platform and is accessed by millions of people each year from over 150 countries. It has been cited in 7,000+ academic publications. In 2019, Amii partnered with DrugBank to support its efforts to build internal AI capabilities. And Amii helped de-risk DrugBank's investment in machine learning and natural language processing. Also in 2019, DrugBank received Startup Canada's Prairie High-Growth Entrepreneurship Award. During the first half of 2020, DrugBank received the inaugural Startup TNT $125,000 investment from Creative Destruction Lab-West to continue scaling its capabilities with 11 new team members. DrugBank provides free, non-commercial datasets to academic researchers. It also offers a free version of DrugBank data and enables ground-breaking research in drug discovery, machine learning and drug repurposing. This research has been used by many prominent organizations worldwide, including the Food and Drug Administration, Health Canada, The National Institute of Health and the World Health Organization.
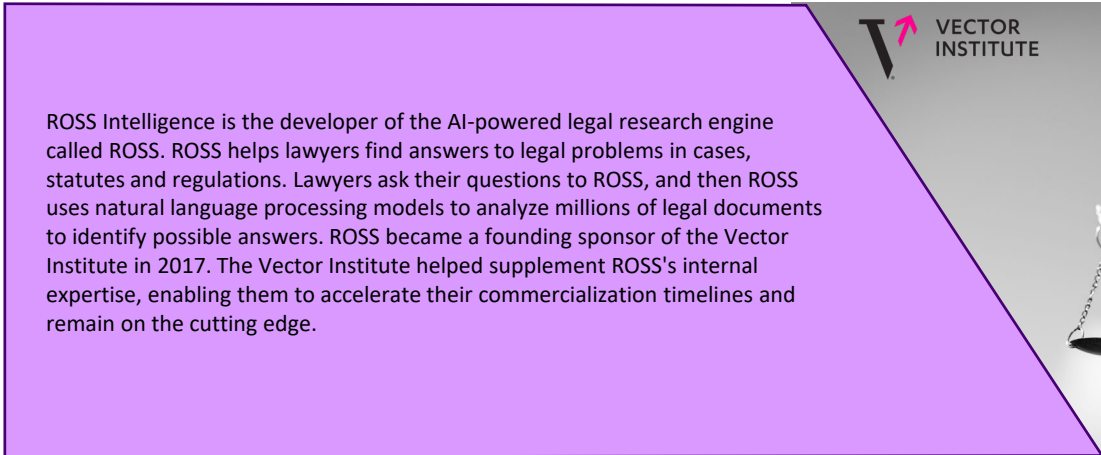
ROSS Intelligence is the developer of the AI-powered legal research engine called ROSS. ROSS helps lawyers find answers to legal problems in cases, statutes and regulations. Lawyers ask their questions to ROSS, and then ROSS uses natural language processing models to analyze millions of legal documents to identify possible answers. ROSS became a founding sponsor of the Vector Institute in 2017. The Vector Institute helped supplement ROSS's internal expertise, enabling them to accelerate their commercialization timelines and remain on the cutting edge.

Giatec develops and manufactures smart technologies for the construction industry. These technologies analyze data to monitor concrete properties and perform quality assurance in more than 6,500 sites worldwide. Giatec was interested in using artificial intelligence to leverage the large amount of data uploaded from sensors. The company partnered with Mila in 2019 to target two main objectives. First, Giatec wanted to automatically infer the moment at which concrete was poured using nothing but data collected by a nearby temperature sensor. Second, Giatec wanted to use deep learning to determine the recipe that requires the minimal amount of cement while still offering the required level of quality. This recipe can have a significant environmental impact and potentially reduce CO_2 emissions. Mila assisted Giatec in transforming its data to a format suitable for training neural networks. Mila then guided Giatec on developing different models and ensured the company acquired experience in using these models. An overarching success throughout this project was the deep focus on transferring knowledge and knowhow to the team at Giatec. This ensured they developed the in-house expertise needed to finish this project and embark on many others.

3.2 RESEARCH & DEVELOPMENT

The AI ecosystem brings together expert minds in highly specialized areas of artificial intelligence, like deep learning and reinforcement learning, to accelerate research and development.

What begins as an idea only becomes reality through research and development. For artificial intelligence, this began as the study of mathematical logic with the hope that machines could do what a human can do. AI has come a long way when considering its inventions and breakthroughs. Canada pioneered the research and development of artificial neural networks. This became one of the corner stones of artificial intelligence. **The Canada CIFAR AI Chairs program retained and recruited 80 world-class researchers in Canada.** This achievement allowed for the continued specialized focus, with a global impact, on deep learning and reinforcement learning. It enabled more research in machine learning. For example, many University of Alberta alumni held important roles in the build of Google DeepMind's AlphaGo program to showcase the capabilities of reinforcement learning. These alumni helped open DeepMind's first satellite lab outside of the UK in Edmonton.[1,2]

Research and development in artificial intelligence is a global effort. Many countries and major enterprises have contributed to this effort. Larger countries have primarily published more artificial intelligence research. From 1996-2019, China published 160K documents, USA published almost 140K, Japan published 48K, India published 46K, the United Kingdom published 42K, Germany published 35K, and Canada published 23K.[3]

In 2019, according to SCOPUS, Canada published **2,054 AI papers with a consistent annual growth rate of 4 percent. Canada maintains a high H-Index (defined below) of 216 and is ranked 4th globally for AI out of 239 countries worldwide.**[3]

Topic	Publications	Citations	H-Index
Artificial Intelligence	Rank 12	Rank 10	Rank 4
Human-Computer Interaction	Rank 8	Rank 8	Rank 4
Modelling & Simulation	Rank 8	Rank 9	Rank 6
Computer Vision & Pattern Recognition	Rank 11	Rank 11	Rank 7

Global Ranking for Canada in R&D from SCOPUS[3]

The H-Index is a measure that "quantifies both journal scientific productivity and scientific impact applicable".[4] The high global H-Index ranking is attributed to many past initiatives and a variety of key players in the Canadian market. To sustain the high ranking and the resulting high impact in research, continued support from the Canadian government and the local Canadian AI ecosystem is required.

The Canadian AI ecosystem has provided the ability to collaborate easily within a niche subject-matter area (e.g. deep learning and reinforcement learning). This support is backed by the Pan-Canadian AI Strategy, Amii, Mila, the Vector Institute and CIFAR's AI Chairs. The ability to collaborate across researchers and experts in the industry accelerates Canadian research and makes it more impactful.
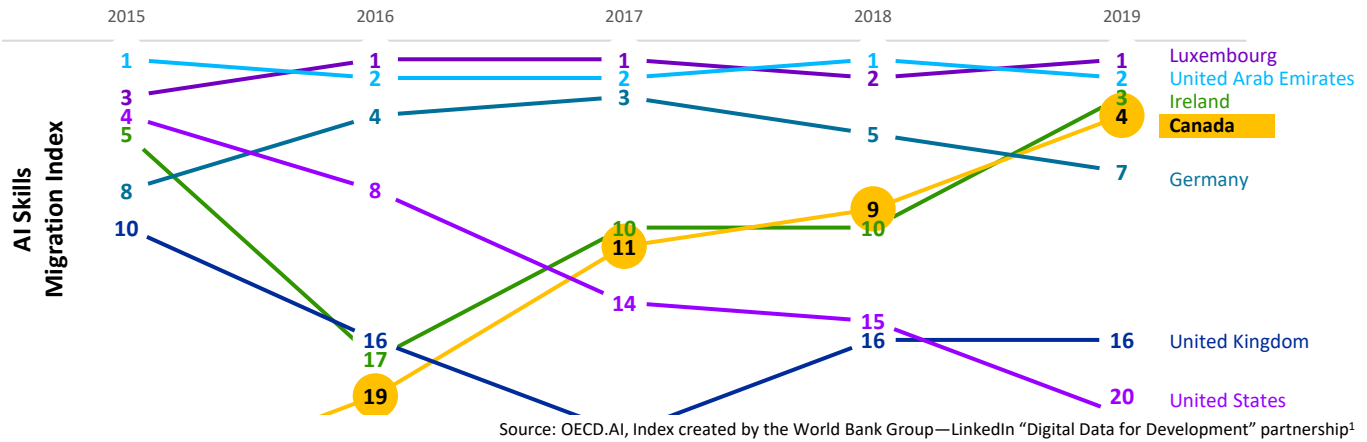
Research and development in AI in Canada is a key contributor to Canadian success in AI. This success led to the creation of several Canadian R&D labs by large international technology companies such as Facebook, Google, and Samsung. And this success enabled the Canadian government to invest **$750 million specifically in artificial intelligence since 2016.**[5,6,7,8,9,10,11,12] The number grows to over a billion dollars when additional initiatives are included where AI is not a focus but is embedded (e.g. the Digital Supercluster in BC and the Next Generation Manufacturing Supercluster in Ontario).

In addition to the research papers, patents are also a great way to measure research and development efforts. With patent analysis however, it must be noted that there is at least an 18-month delay to the patent publication from its submission date.

According to the UK Intellectual Property Office when analyzing AI patents from 1998-2017, Canada **ranked 7th globally from the country of where the applicant/inventor resided in.**[13] **Furthermore, Canada ranked 9th from the global AI patent publication office ranking with respect to where the AI-related patent first originated.**[13] This information shows there are many Canadians building intellectual property in Canada. But it also highlights the potential that there are Canadians developing artificial intelligence IP that originated outside of Canada.

3.3 TALENT (1/2)

Canada has generated and retained a talent pool of highly-skilled individuals. They are continually expanding their research and careers within the Canadian ecosystem.

Source: OECD.AI, Index created by the World Bank Group—LinkedIn "Digital Data for Development" partnership[1]

From 2015 to 2019, Canada increased its rank on the AI Skills Migration Index by twenty spots to 4th place among 55 countries.[1] Talent follows opportunities, and the Canadian AI ecosystem creates jobs and has a reputation which attracts and retains a highly-skilled talent pool. Canada's progress in spawning a flow of talent is based on two key successes:

1. **Developing a globally recognized AI ecosystem and brand.** CIFAR and the AI institutes established a world-renowned brand that generates, retains and draws talent to Canada.
2. **Creating technology jobs through commercialization.** The commercialization of Canadian research generates demand for technology jobs.

By investing in keeping world-class pioneers in Canada, Amii, Mila and the Vector Institute developed a brand that provides opportunities that appeal to high-quality researchers nationally and internationally. Four of the top ten most influential machine learning researchers are leading or working in the AI institutes. This includes Geoffrey Hinton, Yoshua Bengio, Jimmy Ba and Aaron Courville.[2] In 2019, Amii, Mila and the Vector Institute counted 1000 active researchers.[3] The research from the institutes is recognized globally. High-profile international awards have been won by CIFAR-affiliated fellows. Hinton, Bengio and Yann LeCun are Turing Award winners, the award known colloquially as the Nobel Prize in computing. The country has become a talent hub for AI as a result of the efforts to keep researchers in Canada.

Turing Award 2018
Yoshua Bengio,
Geoffrey Hinton

AI 2000 Most Influential Scholars
Machine Learning 2020
Jimmy Ba, Yoshua Bengio, Aaron Courville, Geoffrey Hinton

Canada's Governor Generals
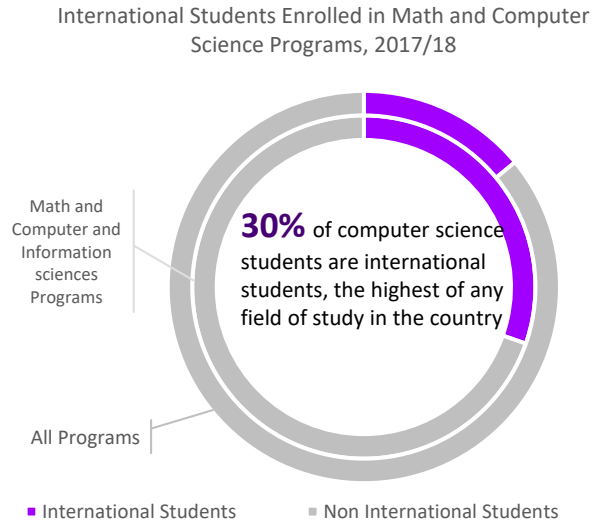**Innovation Award 2019**
Joelle Pineau

Canada's AI job market continues to grow rapidly. Canada is ranked 4th across 50 countries on the LinkedIn AI Hiring Index. This measures the increase in AI job advertisements on LinkedIn globally.[4] The commercialization of AI has driven rapid growth in the employment of skilled labour across technology occupations. Between 2018 and 2019, employment in technology occupations grew by 3.6 percent.[5] Growth in employment across all occupations at the same time was about 1.7 percent.[6] In 2019 there were over 600,000 people employed in technology occupations across the country.[5] Canada has generated a buzz with its exceptional AI career opportunities. It has created an environment for talented and sought-after applicants to progress their careers. And Canada welcomes highly-skilled global talent through the federal Global Talent Stream work permit. Applications are processed with a service standard of ten-business days.[7] Canada is a leader in a workforce that leverages AI skills across occupations. The country ranked 4th in 2019 in the AI skill migration index across 50 countries.[8] These trends align with the analysis of Real Ventures, a leading Canadian early-stage VC. It notes that these opportunities for AI talent were initially shaped by the loyalty of a few pioneers. However, they're now driven by institutes that create opportunities for and access to world-class AI talent, and policies and infrastructure that support innovation.[9]

The Canadian Occupational Projection System (COPS) expects to add over 100,000 relevant technology jobs by 2028. As AI adoption continues, demand for technology jobs is estimated to grow substantially greater than other occupations. COPS expects to have over 700,000 relevant technology jobs by 2028. It will add 100,000+ jobs in just over ten years. This growth accounts for almost 8 percent of job growth in Canada. However, COPS predicts a shortage of labour in technology jobs.[5] Therefore, there is a continuing need to attract skilled technology labour from abroad as well as train and retain Canadians in computer science, math and engineering.

3.4 TALENT (2/2)

As Canada's AI talent pool grows, it attracts talent from around the world and creates an inclusive environment for talent to develop. This brings diverse perspectives to the AI field and ensures the development of comprehensive solutions.

In 2017/18, 30 percent of math, computer and information sciences students were international students, compared to 14 percent across all programs. This is the highest of any field of study in the country.[1] Canada takes pride in its cultural diversity. It is a strength that Canada strives to carry forward in the field of AI. Attracting international talent brings diverse perspectives to the AI field. And it ensures inclusive solutions are developed. The presence of international students in computer science programs has expanded year over year. It grew from 24 percent in 2015/16 to 27 percent in 2016/17, to 30 percent in 2017/18.[1] These students progress into employment in the technology sector. The Canadian Information and Communications Technology Council (ICTC) has identified immigrants as representing 39 percent of the employed ICT workforce in Canada at the start of 2020.[2] CIFAR, Amii, Mila and the Vector Institute actively invest in drawing international students. CIFAR's Deep Learning Reinforcement Learning Summer School aims to have 50 percent international enrolment. In 2019, the school featured 300 students from over 36 countries.[3]

International Students Enrolled in Math and Computer Science Programs, 2017/18

30% of computer science students are international students, the highest of any field of study in the country

Math and Computer and Information sciences Programs

All Programs

■ International Students   ■ Non International Students

Source: Statistics Canada, Table: 37-10-0163-01

Canada is on par with other countries when it comes to gender diversity. And Canada continues to make good progress in this area. Thirty-two percent of AI papers are co-authored by at least one female. This ranks Canada 9th across 50 countries.[4] Canada's STEM and computer science programs have 38 and 28 percent female enrolment, respectively. This ratio has increased marginally over the past three years. The proportion of female students has remained steady. Yet the number of female students enrolled in STEM was approx. 190,000 in 2018/19. This is up from 165,000 in 2014/15.[1] CIFAR, Amii, the Vector Institute, and Mila are working with partners across Canada on AI initiatives and training programs for women and other underrepresented groups in AI.[5]

|		
Amii AlbertaWomen.AI program: In January 2020, Amii launched a six-month mentorship program. It provided foundational knowledge about AI and connected peers and mentors from a diverse range of backgrounds. The program taught how to best apply knowledge and skills in AI and technology careers. • 188 interactions facilitated • Sessions held in partnership with Deloitte, Servus, Improbable, PwC, IBM and CGI	**Invent the Future: AI Scholars Program for Grade 10 and 11 Young Women:** Canada's first and a two-week summer enrichment program. It's focused on bringing AI expertise, community and mentorship to young women, and is hosted by Simon Fraser University.[6]	**CIFAR's Equity, Diversity and Inclusion (EDI) Action Plan:** A plan which ensures we live our values as an organization. This includes fostering inclusive spaces, providing equal opportunities for all and more opportunities for underrepresented groups. It also focuses on removing unconscious bias from decision-making, providing training and awareness, and committing to diverse groups.[7]

3.5 EDUCATION

Investment in Canadian AI education has enabled Canada's success in AI. Canada is now internationally renowned for developing a higher concentration of PhDs in AI than most other nations. It also sees increasing enrolment in STEM and computer science programs across the country, which is underpinned by a globally recognized academic ecosystem.

Canada saw a 26 percent growth in math, computer and information science enrolment since 2015/16. This is compared to a 3 percent growth in all other postsecondary enrolment.[1] The increased concentration in STEM and computer science programs has been accelerated since 2017. It is consistent at all education levels and drives the talent increase in Canada's AI ecosystem. Canada is internationally known for its expertise in machine learning and natural language processing. And its ability to educate and train undergraduate and master's students provides the talent for Canada's AI startups and corporate roles. In advanced programs, Amii, Mila and the Vector Institutes' members supervised 1200+ trainees in 2019.

Growth in Postsecondary Enrollment by Field of Study
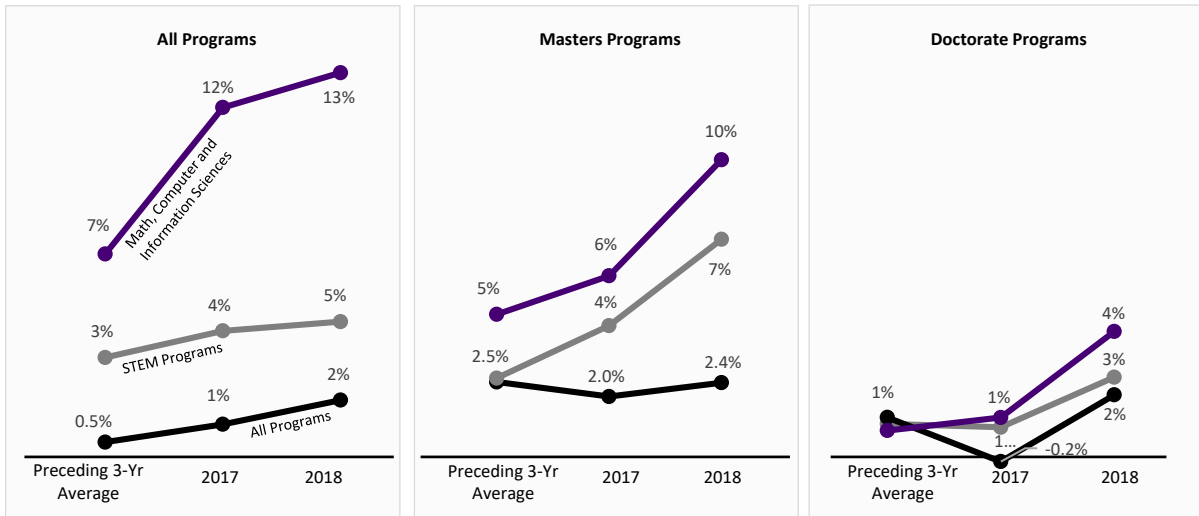
Source: Statistics Canada, Table: 37-10-0163-01

Canada is home to a well-educated population. Twenty-two percent of its citizens hold a bachelors or masters or doctorates. This is slightly above the OECD average of 17 percent.[2] The country boasts strong institutions which consistently produce more PhDs in AI per capita than the UK and Germany. This is measured by the authors of papers in the 21 leading scientific conferences in AI.[3] The investment and focus on Canadian AI education continues to garner global recognition. **Canadian universities consistently rank among the top 100 computer science institutions around the world** as per CSRankings. Three Canadian machine learning programs, as based on the ICML, KDD and NeurIPS conferences, rank in the top 25 CSRankings globally, UofT 14th, UofA 20th, UdeM 24th.[4] Canada's North American rankings (listed below) contend with private universities. These include Carnegie Mellon 1st, Stanford 3rd, MIT 4th, Cornell 5th, Columbia 13th among others (as ranked by machine learning conferences). Canada continues to lead against its public program peers. But continued investment in world-class education will further support Canadian institutions in competing with private programs in the United States and globally.

Canadian Programs Within The Top 35 in North America Based on Number of Publications per Conference

Machine Learning and Data Mining (ICML, KDD, NeurIPS)	**Computer Vision** (CVPR, ECCV, ICCV)	**Robotics** (ICRA, IROS, RSS)
UofT – 7th	SFU – 9th	McGill – 14th
UofA – 17th	UofT – 13th	UofT – 25th
UdeM – 20th	UBC – 31st	UofA – 28th
UBC – 33rd		SFU – 32nd

UofA: University of Alberta
UBC: University of British Columbia
UofT: University of Toronto

SFU: Simon Fraser University
UdeM: Université de Montréal
McGill: McGill University

Source: Computer Science Rankings, 2017-2020[5]

3.6 SOCIAL

As the field of AI expands, so do the social benefits that can be reaped from its progress. Canada has adopted AI across a wide spectrum of social challenges. It has progressed its awareness for the public and professionals. And it has stimulated an open infrastructure that allows individuals and organizations of all sizes to participate.

CIFAR, Amii, Mila and the Vector Institute prioritize the application of AI for Good across societal causes, including health and the environment. Canada consistently ranks in the top 5 for number of AI publications on social and welfare topics. Over 500 publications have been published since 2017.[1] CIFAR drives the agenda on AI for Good through its AI and Society program, a key pillar of the strategy. The AI institutes lead the development of AI for social causes. And they organize initiatives that engage stakeholders from different fields in these crucial undertakings. Canada has seen great progress in the societal applications of AI in numerous settings.

AI for Health: Canada is a leader in exceptional AI for Health research. It is ranked 5th globally for research papers in the top 1 percent for excellence.[1] The development of AI for Health applications is growing. But Canada needs to act quickly and strategically or risk losing its advantage. There is more work to do to translate research strengths to broader adoption of AI in Canada's health systems, according to a recent national AI for Health Task Force.[2]

AI and Society in Education: Institutions embed AI for Society in the way they teach computer science. For example at the University of Waterloo, there are a numerous courses in AI and Society, such as: *Social Implications of Computing; Law, Ethics, and Policy in AI; Human-in-the-Loop Systems;* etc.[3]

Open Data: Canada is the top country in Open Data Barometer's assessment across 30 countries.[4] Canada has over 84,000 open datasets. Companies can use these to build solutions to improve society.[5] Examples include crime action, health sector, land ownership and detailed census datasets.

AI research for COVID-19: CIFAR is funding fourteen AI research projects across the AI institutes to join the fight against the virus.[7] Machine learning research and applications are being used to identify potential treatments. They are helping support public health measures such as social distancing. And they are enabling medical experts to better understand the viral transmission of COVID-19.

Amii Reducing Emissions Through Machine Intelligence (REMI) Program: Launched in August 2020, this program will enable Alberta companies to leverage novel applications of AI to have a measurable impact on emissions reduction in Alberta.[8] Amii will work with a series of industry-aligned cohorts, including agriculture and energy sectors.

AI for Good Summer Lab: The lab focuses on innovative approaches to teaching and learning AI.[9] Its ambitious goal is to tackle diversity and inclusion in AI research. And it aims to inspire the next generation of technical leaders to develop AI as a force for social good. With CIFAR and the OSMO Foundation as founding partners, the AI4Good Lab brings together a cohort of 30 women from across Canada for seven weeks.

AI for Heath in Canada Case Studies[2]

- **AI treatment plans for radiation therapy:** This AI-planning system was developed by UHN researchers. It dramatically reduces the time and associated costs required to generate radiation treatments. And it can create a high-quality treatment plan in minutes.

- **AI Early Warning for Patients at Risk of Needing Transfer to Intensive Care Unit:** The system uses a predictive risk model to make medical recommendations. The system uses machine learning to process regular feeds of health data. And it predicts when a patient needs to be transferred to the ICU.

Public Sentiment on AI: A 2019 study of public sentiment across eight countries found that most Canadians feel neutral on the speed of AI development. However, they are equally divided on speeding up or slowing down/stopping development.[6] Public sentiment on AI is driven by both its impact and its responsible use. As investment in AI continues, the public must be informed on the social areas AI enriches. And they must see it being implemented responsibly.

Public Sentiment of AI Study Across 8 Countries[6]
In general, should the development of AI...?

	Canada	US	Aus.	France	South Korea	Brazil	Nigeria	India
Speed Up	23%	21%	20%	36%	30%	46%	73%	75%
Stay the Same	37%	35%	38%	28%	47%	41%	14%	16%
Slow Down	17%	19%	18%	15%	12%	7%	7%	5%
Stop	6%	8%	7%	7%	2%	1%	1%	1%
Don't Know	17%	18%	18%	13%	8%	5%	4%	4%

3.7 RESPONSIBLE AI

Understanding how AI development considers fairness, accountability, human-centricity, ethics, transparency, and security is crucial.

Canada is a key global leader in developing responsible AI policies. In June 2018, Canada and France founded the Global Partnership on AI (GPAI) during the Canadian G7 presidency. In December 2018, Canada launched the Montréal Declaration for Responsible Development of Artificial Intelligence. And currently in 2020, UNESCO is engaging Mila and Algora Lab (UdeM) to lead a global online consultation on AI ethics. The goal is to build the first global normative instrument to address the developments and applications of AI.

AI is increasingly becoming more embedded into our daily lives. Consider the auto-correct that's built-in directly to our smart phones. Or personalized news feeds. Or the virtual agents that automatically add items to our online shopping basket. AI is making more decisions for us. Therefore, understanding how these decisions are made is critical. Respect to fairness, accountability, human-centricity, ethics, transparency, and security are the key components behind implementing responsible AI.

Montréal Declaration on Responsible Development of Artificial Intelligence[1]
- Recognized internationally as one of the top high-profile initiatives for responsible AI.[2]
- Set of ethical guidelines for the development of AI, led by Université de Montréal in collaboration with the Fonds de recherche du Québec, citizens, experts, public policy makers and industry stakeholders, civil society organizations, and professional orders.
- Built 10 principles and 8 recommendations that promote the fundamental interests of people and groups.

UNESCO's Global Online Consultation on the Ethics of Artificial intelligence[3,4]
- Building the first draft of the global Recommendation on the Ethics of AI with the goal of developing the first global normative instrument to address the developments and applications of AI.
- Mila and Algora Lab (UdeM) lead the deliberative process of consultation that includes 60 online workshops across 25 countries, leveraging their experience in developing the Montréal Declaration.

Global Partnership on AI (GPAI)[5]
- 1st global initiative bringing together 14 individual countries and the European Union led by Canada and France
- Built to guide the responsible development and use of AI, grounded in human rights, inclusion, diversity, innovation, and economic growth.
- One of the two Centres of Expertise to be stood up in Montréal.
- Responsible AI is one of the 4 key focus areas.

In addition, Canada continues to build more initiatives for responsible AI domestically.

In 2019, Canada introduced the **Advisory Council on Artificial Intelligence.** The council is co-chaired by Yoshua Bengio (Scientific Director, Mila, Université de Montréal) and Foteini Agrafioti (Chief Science Officer, RBC). Further support is provided by AI leaders from both public and private sectors across the country. One of the main focuses for the Advisory Council is ensuring that Canadian values are reflected in AI advancements.[6]

Also, in 2019, Canada published the **Canada's Digital Charter.** It is based on public engagement from small business owners and multinational companies to students, teachers, researchers, innovators, entrepreneurs and many more.[7] The charter's 10 principles aim to build a foundation of trust for Canadians in the digital sphere.[8] "The Digital Charter is a government-wide approach that will ensure Canadians can trust new digital technologies and that their data and privacy will be safe. It will ensure that our democratic institutions will be protected, and that Canadians will be able to take full advantage of the many new opportunities unlocked by data-driven technologies."[8]

Furthermore since 2019, Canada continues to review existing regulatory requirements. And it is conducting a reform of the **Personal Information Protection and Electronic Documents Act (PIPEDA).**[9] This reform aims to build additional regulation that creates the conditions for trust in the digital economy to flourish. And it seeks to protect the fundamental rights of Canadians.[10]

Canada's contributions on responsible AI are valued and recognized worldwide. Continued focus on responsible AI will help Canada make improvements both domestically and internationally as a global leader.

4.1 ALBERTA

#2 global rank for AI & ML on CSRankings ('98-'19)[1]

Tripled the number of reinforcement learning papers 2017 to 2019[2]

#1 Tech Talent Score Improvement in CBRE Canadian Tech Talent report 2019[3]

Alberta offers world-class research in reinforcement learning. It is led by one of the founding pioneers, Richard Sutton. The Pan-Canadian AI Strategy and Amii helped develop an AI ecosystem centred around this research. Since 2017, Amii has attracted foreign investment, improved computer science education programs, and expanded the technology sector in the province.

Research excellence: Amii has 23 fellows and 209 active researchers. It published 306 peer-reviewed publications in 2019/20.[4] The University of Alberta (UofA) is ranked second in the world for AI and ML research output on CSRankings (1998 to 2019).[1] The University of Alberta grew its number of AI publications by 30 percent. And it accounts for almost 1 in 6 of all AI publications in Canada. Amii is a global leader in reinforcement learning. The University of Alberta's number of publications tripled in this field from 2017 to 2019 with 51 papers published in 2019. This contributed 26 percent of reinforcement learning papers in Canada.[2]

> "**Once known as a mining and energy town, Edmonton is now one of the world's leading centres for a decidedly different industry—machine learning. The Department of Computer Science at the University of Alberta is playing a leading role in building the city's high-tech reputation.**"[7] – Maclean's

Education: Amii's excellence in research, globally renowned researchers and over 49 events in 2019/20 with 3050 attendees helped attract students to Alberta's AI and computer science programs. Enrolment in mathematics and computer and information sciences programs in Alberta grew by 20 percent from 2015/16 to 2017/2018. Overall enrolment grew by 4.5 percent during the same period. Alberta's research recognition has led to increased foreign student enrolment. A quarter of Alberta's computer science and math programs are now made up of international students.[5] The University of Alberta's computer science department has over 40 faculty members. Fifty percent of those work directly on AI or machine learning.[6] It is one of the only Canadian schools that offers a reinforcement learning course at the bachelor level. And it is one of few to offer it at the master's level.[7] As a result, Alberta is generating skilled talent that flows into the workforce.

Sloan Research Fellow
2017
Mark Schmidt (UBC & Amii)

Canadian AI Association's Lifetime Achievement Award
2018
Richard Sutton (UofA & Amii)

Association for the Advancement of AI (AAAI) Elected Fellow
2017 *Dale Schuurmans (UofA & Amii)*
2018 *Kevin Leyton-Brown (UBC & Amii)*

Talent: Alberta's technology sector has grown from several interconnected factors. These include Amii's specialized research, R&D generated by that research, and the increase in computer science students drawn to the research centre. In Calgary and Edmonton in 2018, the technology sector represented 5.5 percent of jobs in the city with 38,500 employed and 4.2 percent of employment with 28,400 tech workers, respectively. **In the 2019 CBRE report on Canadian Tech Talent, Edmonton saw the largest score improvement of any market in Canada from 2018 to 2019.**[3]

March 2017 IBM and the District Ventures incubator launch their Innovation Space in Calgary.	*April 2018* ATB Financial partners with UofA for research in AI and ML.	*April 2019* Edmonton hosted the SingularityU Canada Summit.	*November 2019* Scotiabank AI Research Initiative is launched with UofA.	*July 2020* Drivewyze receives $60M investment to scale its connected truck platform.
2017	**2018**	**2019**		**2020**
July 2017 DeepMind chooses Edmonton for its 1st international lab.	*November 2018* UofA receives $2.5 million for an AI-supercomputing hub.	*May 2019* Amii's supported FunnelAI raises seed funding.		*May 2020* Edmonton-based MEDO.ai initiates pilot of AI-augmented 3D ultrasound platform.

Connection to industry: Amii partners with industries to discover and commercialize AI applications. It's developed 49 formal industry partnerships, including with Imperial Oil and Climate Corp. The institute has attracted $21 million in industry funding.[4] DeepMind (Google), RBC, and Mitsubishi Electric have opened new research labs in Edmonton to partner with Amii researchers. In addition, Google Brain, Google Research, Microsoft Research, IBM Research and Volkswagen Data Lab conduct collaborative research through Amii.[6] Alberta has a thriving startup ecosystem that supports technology adoption. Startups such as AltaML pursue the commercialization of AI. Startup Genome values Calgary's startup ecosystem at $1.2 billion.[8] This is supported by a vibrant innovation community. It includes accelerators and incubators such as Creative Destruction Lab Rockies, Alberta Innovation Corridor, Startup Edmonton and Platform Calgary. Amii is a key part of growing this ecosystem. Amii alumni have received $330+ million in venture financing in Canada. Amii-affiliated companies based in Alberta have received $110+ million.[4]

AltaML—an Edmonton founded startup—conceptualizes, develops, and commercializes ML software products: It is led by Cory Janssen, a University of Alberta alumnus. AltaML serves as a bridge between cutting-edge academic research and commercialization in industry.[9] The company has expanded to Calgary and Toronto. And it received $32.5 million in funding from Opportunity Calgary Investment Fund.

DeepMind opens 1st international lab in Edmonton (2017): The lab opened in close collaboration with the University of Alberta. It is led by Amii's Richard Sutton, Michael Bowling and Patrick Pilarski. The collaboration hopes to turbocharge Edmonton's growth as a technology and research hub.[10]

4.2 ONTARIO

#1 **tech job creation in North America (Toronto)**[1]

50% of nation's math/CS/IS students enrolled in Ontario[2]

$17+ billion USD of value in startup ecosystem in Ontario[3]

Ontario has the largest GDP of any province. It is also one of the key leaders in the commercialization and research of AI. Since the Pan-Canadian AI Strategy investment, the **Ontario government invested a further $60 million, with the private sector investing an additional $45 million.** The AI ecosystem is backed by CIFAR and the Vector Institute. It generates strong economic and social values for the Ontario region. And it has contributed heavily to the growth of technology job creation, the startup ecosystem, and research collaborations.

Many organizations in Ontario have adopted and commercialized AI in the past several years. For example, TD Bank acquired and integrated with Layer 6 (AI startup) in 2018. In the same year, the government committed to the Next Generation Manufacturing Supercluster where AI will be heavily adopted. In 2020, Deep Genomics heavily focused on AI and raised $40 million in series B financing. And Shopify experienced an exceptional rise in market share thanks to its AI-embedded digital platform.[4]

The rise of AI contributes to economic growth. In 2018, Statistics Canada estimated that there are 370,000+ technology jobs in Ontario.[5] In 2019, **Toronto was named the #1 Fastest Growing City for Tech Jobs in North America. And it rose to #3 in Tech Talent Ranking.**[1,6]

The Ontario startup ecosystem valuation is valued at more than $17+ billion USD.[3] It has greatly impacted the AI industry. Surgical Safety Technologies was named as one of the Best Inventions in 2019 by Time Magazine.[7] Eight Canadian startups made CB Insights' global AI100 list.[8] And the Vector Institute played a key role in developing partnerships with the private sector. It now has 47 industry sponsors. These represent a significant portion of Canada's largest and most successful companies and emerging startups.

> **"When it comes to AI talent, Waterloo, and Ontario in general, are quite exceptional… The amount of runway that we get with say a million dollars is 40 to 50 per cent more than what you would get if you located your company in San Francisco. Economically, that's a real benefit."**
> – Darwin AI[9]

2018	2019	2020
January 2018 Layer 6, Toronto-based AI startup, acquired by TD Bank.	*May 2019* Collision conf. hosted in Toronto with 25,000+ attendees.	*June 2019* Mindbridge AI raises $29.6 million in series B financing.
April 2018 Waterloo Artificial Intelligence Institute (Waterloo.ai) launched.	*May 2019* Ottawa officially opens L5 test facility for autonomous vehicles.	*January 2020* Deep Genomics raises $40 Million in series B financing.

February 2020 Dessa, focused on building ML applications, acquired by Square.

July 2020 Shopify hits $1,000 stock price with 96% yoyo growth rate.

March 2020 Ada raises $63.7 Million in series B financing.

Ontario has also shown strong growth in math/CS/IS program enrolment. The province has experienced a 12 percent annual growth rate for math/CS/IS students. And it accounts for over 50 percent of math/CS/IS students nationwide.[2] Also, 50,000 out of 230,000 students in Ontario are enrolled in STEM programs.[2] Ontario has seven fellows elected in the prestigious Association of the Advancement of AI (AAAI) program. The Vector Institute and the University of Toronto have been widely recognized for the quality of their researchers. They are rightfully seen as global leaders in deep learning and machine learning (see awards section to the right). In addition, the University of Toronto and the University of Waterloo are ranked #1 and #3 respectively for their computer science programs within Canada.[10]

Turing Award
2018
Geoffrey Hinton (*UT & Vector Institute & Google*)

AI 2000 Most Influential Scholars
Machine Learning
2020
Geoffrey Hinton (UT & Vector Institute & Google)
Jimmy Ba (UT & Vector Institute)
Richard Zemel (UT & Vector Institute)
Jamie Ryan Kiros (UT)
Roger Grosse (UT & Vector Institute)
Alex Graves (UT)

Robotics: Science and Systems Foundation
Early-Career Spotlight Award 2019
Angela Schoellig (UT & Vector Institute)

Startup community in Ontario: An actively supported community comprised of the government, universities, incubators/accelerators, and venture capitalists. Examples include Velocity from the University of Waterloo, MaRS and Highline Beta as accelerators, and OMERS and Georgian Partners as VCs.

Shopify becomes Canada's largest public company: With its meteoric rise in 2020, Shopify displaced RBC as the largest public company in Canada. It posted an increase of almost double its revenue in Q2 in 2020.

CS: Computer Sciences
IS: Information Sciences

4.3 QUEBEC

Ranked #1 in Prestige globally for AI Research (UdeM)[1]

UdeM and McGill ranked Top 5 Computer Science programs in Canada[2]

Montreal voted **"Best city to invest in AI"**[3]

Quebec is home to the Montreal and Quebec City AI ecosystems. It's led the world in deep learning and machine learning research.[4] Some think Montreal's "atmosphere of fellowship and belief that scientific progress should be shared by everyone" has made the province a hotbed for specialized research.[5] But it's the support, investment and development of the AI ecosystem that has helped attract talent to universities, academia and the economy. This convergence of talent, opportunity and investment in the province is led by some of the top AI researchers in the world.

The Pan-Canadian AI Strategy investment in Quebec's AI Institute, Mila, along with investments by the Province of Quebec, have catalysed a cross-provincial ecosystem. It consists of 450 researchers specializing in machine learning. Their mission is to become a global pole for scientific advances. Mila develops globally renowned expertise in AI for Health, deep learning and reinforcement learning, and responsible AI. The community is known for its deep-rooted exchange of people and ideas between the public and private sectors. And it includes one of the largest researcher communities appointed in private sector companies. For example it includes Joelle Pineau of Facebook, Simon Lacoste-Julien of Samsung, and Doina Precup of DeepMind.

Turing Award
2017-2018
Yoshua Bengio (UdeM & Mila)

AI 2000 Most Influential Scholars Machine Learning 2020
Yoshua Bengio (UdeM & Mila)
Aaron Courville (UdeM & Mila)
Sherjil Ozair (Mila)
Dzmitry Bahdanau (UdeM)
Hugo Larochelle (Mila)

Canada's Governor Generals Innovation Award
2019
Joelle Pineau
(McGill University & MILA)

Quebec's major AI universities, Université de Montréal and McGill University, along with Mila, attract top postdoctoral and PhD talent from all over the world. The two universities develop well-rounded research. Together, they published over 600 AI papers in 2019. This is a 40 percent increase since since the two-years prior.[6] Université de Montréal gained notable prestige through these publications,

> **"The major difference between Montreal and many other technology hubs is the atmosphere of fellowship and the belief that scientific progress should be for everyone."** – Real Ventures

ranking 1st in AI, 2nd in reinforcement learning and 3rd in deep learning.[6] The strong academic and research community draws substantial investment from firms. These firms establish R&D labs within the province to gain access to Quebec talent. Since April 2017, investment into 18 R&D labs has driven substantial growth in AI.[7] Specifically, in the commercialization of research and the hiring of talent. Notable investments include:

April 2017	October 2017	January 2018	October 208	May 2019
IBM opens an AI lab in Montreal to better collaborate with Mila.	DeepMind opens laboratory in Greater Montreal, bets on strong research community.	Microsoft expands its Montreal research lab and doubles staff to 75.	BIOS opens AI centre in Montreal.	Samsung Electronics expands to Spur Next-Generation Semiconductor.

2017	2018	2019

September 2017	November 2017	September 2018	December 2018
Facebook launches AI research lab (FAIR) in Montreal.	Borealis AI (RBC Institute for Research) to open new AI lab in Montreal.	Varian Medical Systems creates centre of innovation in Greater Montreal, triples staff count to 60.	WinningMinds opens AI centre in Montreal.

This investment further strengthened the Quebec startup ecosystem. Its worth is now estimated at over $9 billion. Montreal, ranked 5th most affordable talent pool in North America, is ranked the best student-talent city in the Americas.[8] Quebec City, ranked top 10 best "Bang for Buck" and has seen VC investment grow 133 percent during 2017-2018.[9] Both ecosystems, known for their AI, Big Data & Analytics, and Life Science sector strengths see continued investment. Most notably in SCALE AI, Montreal's seven AI accelerators, nine research centres and local startups such as Element AI, Stradigi.ai and Dialogue, which raised over $450 million combined.[8]

ELEMENT AI Based in Montreal, with offices now in Toronto, London, Seoul and Singapore, Element AI is a specialist AI company. It provides organizations with unparalleled access to cutting-edge technology through as-a-service offerings. Considered an "emerging unicorn",[10] Element AI raised over $250 million from more than 17 investors. This support made it the "world's largest AI startup Series A".[11]

SCALE|AI The Montreal-based Canadian AI Supercluster focuses on the integration of AI in industry. It identifies cross-sector collaborative projects. And it provides funding and expert guidance. With $230 million of federal funding and $53 million from the Government of Quebec, Scale AI aims to add $16.5 billion to Canadian GDP and create 16,000 jobs.

4.4 BRITISH COLUMBIA (B.C.)

Top 25 Best Startup Ecosystem in the World[1]

43% growth in technology employment in Vancouver[2]

#1 rank of SFU in computer vision in Canada on CSRankings[3]

British Columbia has a thriving high-technology industry. This enables the province to grow an AI ecosystem that is embedded in diverse technology applications. For example, B.C.'s specialization in computer vision research propels its interactive gaming/virtual reality technologies, as well as its animation and film industries.

Research excellence: British Columbia is home to one of the oldest video game clusters in North America.[4] This has made B.C. the ground for advances in the AI field of computer vision. B.C. is home to universities that advance research in AI. This includes the University of British Columbia (UBC) and Simon Fraser University (SFU). CAIDA is UBC's main AI research organization. It consists of over 100 professors and their research associates.[5] UBC contributed 17 percent of Canada's AI publications in 2019, equal to 404 publications.[6] SFU is ranked the number one university in computer vision in Canada on CSRankings (2010 to 2020) and 11th in US and Canada.[3]

Talent: Employment in technology occupations in Vancouver has grown by almost 43 percent from 2013 to 2018. Victoria saw growth of 16 percent in technology employment over the same period. Together, the cities employ approx. 85,000 people in technology occupations.[2] This momentum in the technology sector is spread across a variety of high-tech domains through which AI is applied.

Education: MacLean's ranks UBC's computer science program as the number two computer science program in the country.[8] The province saw 20 percent growth in mathematics, computer and information sciences enrolment from 2016/17 to 2018/19. This is compared to 5 percent growth across all programs. B.C.'s computer science and math programs attract global talent. **Forty percent of students enrolled in math, computer and information sciences in B.C. are international. This is the highest of any field of study in the province.**[8]

Progress in Gender Diversity: According to Trade and Invest B.C., Vancouver's AI industry attracts many female engineers and company leaders. The city's chapter of Women Who Code, a global non-profit organization supporting women in technology, has over 1,600 members. B.C. has 40 percent female enrolment in STEM programs in 2017/18. This is highest in the province and has steadily grown this proportion over the past three years.[8]

The Athena Pathways Program for Women: To continue to address the talent gap, the AI Network of British Columbia (AInBC), alongside a few key partners, is leading this program. It will connect 500 women to career paths in AI and data science.[15]

Commercialization: One of B.C.'s strengths is the commercialization of AI across technology applications.

Startup Genome values Vancouver's startup ecosystem at $10 billion. It ranks it as the 24th best startup ecosystem in the world.[1] B.C. has more than 140 AI and machine learning startups in this booming startup ecosystem. It also has 20+ startups in computer vision.[10] In 2019, Vancouver hit a six-year high for funding across all startups, at $924 million dollars raised.[11] These startups have advanced AI applications embedded in gaming, AR/VR, cleantech, and other high-tech industries. These applications are further adopted with the help of organizations such as the **Digital Technology Supercluster. The vision of this supercluster is to position Canada as a global leader in digital technology. This will be achieved by unlocking the potential of data in the era of intelligent enterprise.** The supercluster has secured investment commitments of over $360 million. It is one of the catalysts pushing AI adoption in B.C. and across the country.[12] The Artificial Intelligence network of British Columbia (AInBC) is another key organization. It helps to bring companies and academic leaders together to drive adoption and catalyze AI and ML communities.[13]

B.C.'s ecosystem attracts multinational companies. Fujitsu opened its global AI headquarters in Vancouver in 2019. Borealis AI, the Royal Bank of Canada's (RBC) institute of research, expanded its network of labs across Canada into Vancouver in 2019. The new research centre is focused on computer vision. It aims to progress applications in financial services.[14] AI applications in B.C. are embedded across its high-tech sectors. Therein lies the strength of the AI ecosystem in B.C.

Fujitsu's new global AI headquarters office opens in Vancouver (2019): The Tokyo-based multinational IT company chose Vancouver as its headquarters. In particular, it wanted to work in collaboration with a variety of organizations and companies, and the rich and diverse startup ecosystem.[16]

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APPENDIX

METHODOLOGY

The scope of work included identifying a series of key performance indicators across six domains in order to evaluate the impact of the Pan-Canadian AI Strategy since its inception.
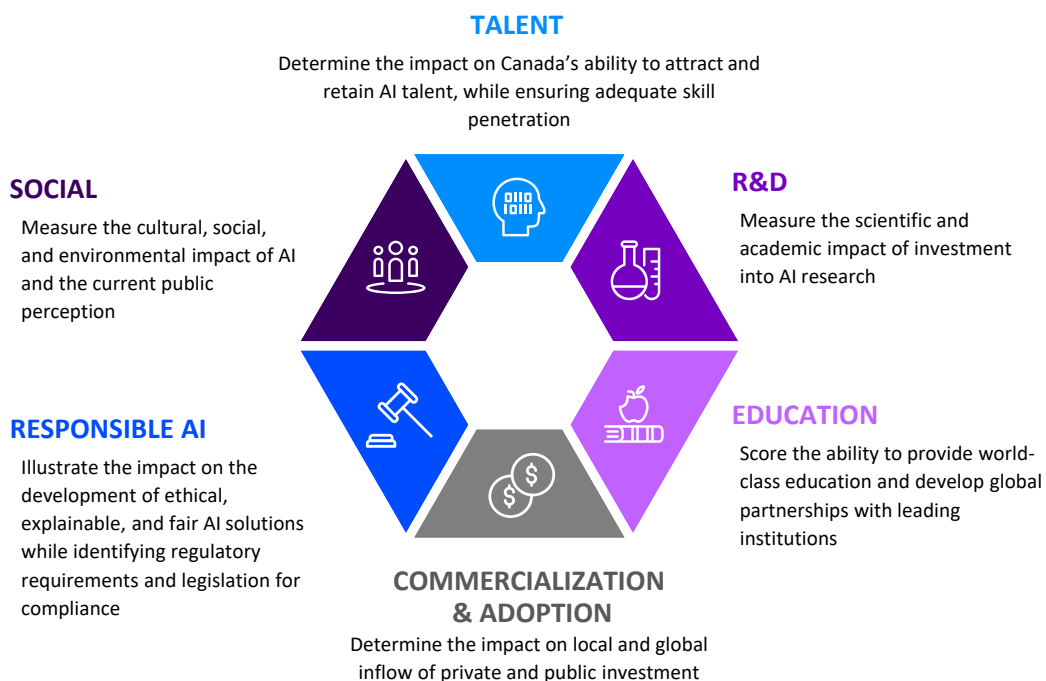
Evaluation Scope, Objectives and Approach: The goal of this assessment is to evaluate the impact of the Pan-Canadian AI strategy since its inception. The scope of work included:
- Identifying a series of key performance indicators for the Pan-Canadian AI Strategy, including indicators to evaluate the economic and social impacts of the strategy.
- Collecting and analyzing the data on those key performance indicators while understanding the assumptions behind each data point.
- Describing the strength of the AI ecosystems in Canada, both regionally and nationally, based on the data analysis and research.
- Describing the overall impact of the Pan-Canadian AI Strategy to date.

To evaluate the impact of the strategy on its five key objectives and its socio-economic benefits, six-domains were identified. These domains were selected using Germany's *"Comparison of National Strategies to Promote Artificial Intelligence"[1] and "U.K.'s AI Sector Deal – One Year On"[2]* reports as a guideline. Domains were added and adjusted (e.g. responsible AI) based on the elements that are important to CIFAR's strategy.

Each domain was mapped to the key objectives that CIFAR set out to achieve and a quantitative and qualitative analysis was conducted to provide an initial "top-down" evaluation of the strategy. Discovery sessions identified key questions which drove the analysis of over 50+ KPIs mapped to the domain categories. Domain questions used for the analysis can be found in the appendix.

The evaluation is intended as an initial discovery exercise to understand the high-level impact of the Pan-Canadian AI Strategy Program. The data or the assessment of key performance indicators is pulled from public sources in addition to internal CIFAR data available. The quality and recency of data is based on the publicly available information.

TALENT
Determine the impact on Canada's ability to attract and retain AI talent, while ensuring adequate skill penetration

SOCIAL
Measure the cultural, social, and environmental impact of AI and the current public perception

R&D
Measure the scientific and academic impact of investment into AI research

RESPONSIBLE AI
Illustrate the impact on the development of ethical, explainable, and fair AI solutions while identifying regulatory requirements and legislation for compliance

EDUCATION
Score the ability to provide world-class education and develop global partnerships with leading institutions

COMMERCIALIZATION & ADOPTION
Determine the impact on local and global inflow of private and public investment

1. Germany's Report on Comparison of National Strategies to Promote Artificial Intelligence: https://www.kas.de/en/web/guest/single-title/-/content/vergleich-nationaler-strategien-zur-forderung-von-kunstlicher-intelligenz
2. UK AI Sector Deal – One Year On: https://www.gov.uk/government/publications/artificial-intelligence-sector-deal/ai-sector-deal-one-year-on

DOMAIN QUESTIONS

Defining objectives for each domain to help guide scope definition, research approach and main questions to be investigated.

3.1 COMMERCIALIZATION & ADOPTION

Translating AI research discoveries into application in the public and private sectors leading to socio-economic benefits

1. What does the Canadian AI startup ecosystem look like and how has it changed over the last 3 years? (# of companies)
2. What does investment in Canadian AI startups look like?
3. How successful are Canadian companies at scaling up vs. acquisition?
4. How focused is the innovation ecosystem (incubators/accelerators) on supporting AI startups?
5. How actively is the private sector adopting AI?

3.2 RESEARCH & DEVELOPMENT

Enhancing Canada's international profile and visibility in AI research and training and increasing productivity in AI academic research and enhanced capacity to generate world-class research and innovation

1. What is the public sector investment in AI R&D?
2. What is the private sector investment in AI R&D?
3. What is the investment in R&D infrastructure?
4. What is the volume of AI research in Canada (pubs)?
5. What is the quality of AI research in Canada (citations)?
6. How is Canadian AI IP being protected and commercialized? (patents, licenses)

3.3 TALENT

Attracting and retaining AI talent in Canadian universities and industry; development of AI research capabilities through a palette of training opportunities

1. How many of the world's top AI researchers work in Canada?
2. How have Canadian AI talent pools changed over time? How do they compare to other jurisdictions?
3. What are the inflow/outflow trends in AI talent in Canada? How has that changed over the last few years?
4. What do the AI job markets look like in each region?
5. How easy is it for AI grads to get jobs?

3.4 EDUCATION

Enhancing Canada's international profile and visibility in AI research and training

1. How does Canada compare in # of AI grad students, # of AI grad and undergrad programs?
2. How do our CS departments rank internationally in AI?
3. How does Canada compare overall for STEM enrolments and graduates?

3.5 SOCIAL

Translating AI research discoveries into application in the public and private sectors leading to socio-economic benefits

1. How does Canada compare with respect to equity, diversity and inclusion in AI?
2. Is Canada having an impact on AI for social good (e.g. health, transportation, environment, social services, etc.)?
3. How does the Canadian public feel about AI?
4. How much are Canadian AI researchers engaging with the public?
5. How does Canada compare in developing and advancing policies related to AI?
6. How available is public data for AI research and innovation?

3.6 RESPONSIBLE AI

Increase collaboration across the AI ecosystem to define and comply to the responsible use of AI

1. What are Canada's strengths in responsible AI?
2. What impact is it having in Canada and around the world?
3. What is Canada doing to further advance the topic of responsible AI and to enforce it