The Economic Geography of Canada's AI Ecosystem

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Abstract

Canada’s artificial intelligence (AI) sector is receiving significant interest and investment from governments across Canada. These investments target emerging clusters of AI startups across the country and follow an expectation that AI will have substantial economic and societal impacts as a general-purpose technology. However, to secure venture capital, these startups become subjects of global financial networks, dictating their development trajectory. This project investigates Canada’s AI ecosystem’s financialization dynamics within the context of global financial networks and their interplay with the spatial distribution of the AI startups’ agglomeration effects.

By adopting a mixed-methods approach that included constructing a database, interviews, and policy analysis, I found that the Government of Canada has facilitated the ecosystem's growth, but it has not internalized the benefits of its investments successfully. Furthermore, while Canadian AI clusters have developed distinct entrepreneurial atmospheres from each other, they commonly rely on foreign investments and markets, especially from the US.

Dedication

I dedicate this thesis to my loving parents Forouzan Dehbashi Sharif and Naser Babashahi Ashtiani, and my older brother, Kia Babashahi Ashtiani. They inspired me to pursue this degree, and without their support, I could never have finished it.

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Chapter One: Introduction

In 2017, the Government of Canada announced the Pan-Canadian National AI Strategy, a 5-year plan that included $125 million in investments for the development of Canada's artificial intelligence (AI) tech sector. This plan was one of several initiatives launched by the Canadian government focusing on developing Canada's tech industry. The Innovation Superclusters Initiative launched in 2017 was another program that included $980 million in investments to expand five tech superclusters across Canada, 3 of which focused on AI.

Provincial governments across Canada added significant complementary investments to these amounts; notably, Quebec and Alberta invested $100 million each, and Ontario invested $80 million. Various policy expectations configured the development of this strategy, such as AI's potential as an enabling or general-purpose technology, the increasingly technoscientific characteristic of contemporary capitalism, and an already existing infrastructure that supports AI research and development (Klinger et al., 2018).

According to the Canadian Institute For Advanced Research (CIFAR), the organization tasked by the Government of Canada (GC) to lead Canada's national AI strategy, the Canadian AI ecosystem is thriving. Based on their latest annual report (Canadian Institute For Advanced Research, 2020a), in 2019 alone, Canadian AI startups raised more than $658 million in venture capital funding, which was 49 percent higher than the previous year. However, the report does not mention that Element AI - a Montréal-based AI startup founded in 2016 – was responsible for raising $200 million of this amount. This fact is relevant because ServiceNow - a US-based company - acquired Element AI in November 2020. At that point, Element AI had filed for more than 90 patents, all of which transferred to ServiceNow.

The acquisition of Element AI was not a unique phenomenon in the Canadian AI ecosystem. There are numerous possible implications of the outflow of talent, intellectual property (IP), and returns on public and private investment that occur with such events. If Canada wants to capitalize on the potential of artificial intelligence as a general-purpose technology, it is important to examine who eventually benefits from Canada's investment in AI.

Canada's position as a leader in AI research and development is not a fluke; it is due to the efforts of Canadian publicly- and privately-funded researchers. By the early 1990s, With little to show in terms of practical application, AI had failed to deliver on its long list of promises. (Bergen & Wagner, 2015) Private funds were diminishing, and many governments, including the USA and Japan, discontinued their AI programs. This period was called the "AI winter". However, In Canada, a group of researchers at CIFAR, based out of the University of Toronto, continued their research on AI, leading to the publication of their deep learning algorithms in 2006 that revolutionized the use of AI (Bergen & Wagner, 2015; Association for Computing Machinery, 2019). This research was led by Geoffrey Hinton, Yoshua Bengio, and Yann LeCun, who won the 2018 Turing award (often referred to as the equivalent of the Nobel prize for computer science) for their work on deep learning.

In 2007, a year after Hinton and his colleagues made a breakthrough in deep learning[1], Jonathan Schaeffer at the Alberta Machine Intelligence Institute (Amii) - a research center founded by the University of Alberta in 2002 – successfully solved checkers. A game is solved when its outcome can be correctly predicted from any position. Schaeffer used AI to carry out 10^{14} calculations over 18 years, creating an endgame database of 39 trillion positions (Schaeffer et al., 2007). This feat was a testament to AI's computing prowess. The success of Canadian AI researchers continued in the 2010s, with University of Toronto researchers making breakthroughs in speech recognition (G. Hinton et al., 2012) and computer vision (Krizhevsky et al., 2012).

Canada's achievements in the world of AI revolve primarily around academic research. Thus, CIFAR has centered the Canadian AI strategy around three prominent national research institutes that center their affiliated hubs: the Vector Institute for Artificial Intelligence at the University of Toronto; Amii at the University of Alberta; and the Montréal Institute for Learning Algorithms (Mila) at the Université de Montréal. These institutes attract and train talent and stimulate business development with their incubator and accelerator programs.

Policy interest and public investment in AI follow an expectation that it will generate significant societal benefits for Canadians, including new and high-paid jobs, new products and services, and new investment opportunities. The question then arises, is the emerging AI sector actually doing these things?

[1] Deep Learning is a form of machine learning that enables computers to learn from experience and understand the world in terms of a hierarchy of concepts (Goodfellow et al., 2016).

Current research predicts that AI will become a general-purpose technology (GPT) in the foreseeable future (Dafoe, 2018; Goldfarb & Trefler, 2018; Trajtenberg, 2018; Furman & Seamans, 2019). However, a key characteristic of the emerging digital economy to which AI contributes is shifting from prevailing modes of ownership to new relationships centered on borrowing, licensing, and leasing (Perzanowski & Schultz, 2016). This shift has many implications: for example, AI research and development produces intangible "knowledge assets" that attract a high degree of speculative financing. The search for short-term returns defines the increasing financialization of our economies (Dosi et al., 2016), which forces companies to shift their focus from long-term innovation strategies to short-term objectives; in short, it can hinder their capacity to focus on long-term outcomes.

Furthermore, the financialization of innovation, including AI, provides the recipe for the extraction of economic rents by turning data and personal information into an asset. Rentiership, as opposed to entrepreneurship, necessitates creating property rights, regulations, and limiting competition, in order to control markets rather than incentivize the production of new goods and services (Birch, 2017a).

In analyzing financialization dynamics, this work has been informed by previous research on global financial networks (GFN) that looks at global production networks (GPN) and global value chains (GVS) through a finance lens and considers them to be fundamental to all economic activities(Coe et al., 2014). Canadian AI startups are at the receiving end of an increasing flow of foreign direct investments (Canadian Institute For Advanced Research, 2020a), and as part of GVSs, many startups provide services to businesses abroad. Hence, policymakers in the sector require substantial knowledge of assets within their regions and how they relate to the needs of global production networks outside their region (Coe et al., 2004).

Additionally, Canada provides significant equity-free benefits to its AI startups, hoping that they will stimulate the economy, but when foreign companies acquire these startups, part of those contributions go without seeing any reciprocation. Such acquisitions can limit Canada's influence in the tech industry and make it more susceptible to foreign policies; for example, Amazon refuses to hire Iranians even in Canada because of US export control laws and regulations(Dunham, 2020).

This project falls under the umbrella of a greater Social Sciences and Humanities Research Council (SSHRC)-funded research project titled "From Entrepreneurship to

Rentiership? The Changing Dynamics of Innovation in Technoscientific Capitalism", led by Dr.Kean Birch as the principal investigator with the goal of examining the extent, manifestation, and policy implications of 'rentiership'[2] in contemporary, technoscientific capitalism, and with its exponential growth, the Canadian AI sector was one of the Insight grant's areas of interest. In the hopes of shedding light on the unique dynamics that govern Canada's AI ecosystem and the financial flows that sustain it, I conducted a three-stage investigation and organized the results into four sections of the thesis.

The first of these sections is section 4, the policy discourse that comes after the methodology section. This section includes the results of a critical discourse analysis of Canadian policy and government documents related to the AI sector. It provides insight into how the GC views the AI ecosystem, its vision for its future, and its strategies to realize those visions.

Section 5 of the thesis examines geographic clusters in the AI ecosystem. As part of my research, I constructed a database of Canadian AI companies, their funding information, and the location of investors in the sector using data from a business information platform called Crunchbase. In section 5, I compare the AI ecosystem's spatial configuration from the GC's perspective with the distribution of its companies according to the database. I further analyzed the results against scientific literature and the opinion of experts, which were senior and executive-level professionals working in Canada's AI tech sector that I had interviewed.

The analysis in section 6 follows a similar framework to section five; however, it is about the financial flows that sustain Canada's AI ecosystem. I organized it into three subsections, levels of investment in AI companies across Canada, the sources of those investments, and the post-exit capital flows that highlight the ultimate beneficiaries of public investment in the ecosystem. The final section is the cumulation of the study's most critical findings and their implications for policymakers. Together these sections highlight the implications of economic geography for the development of Canada's AI ecosystem.

[2] Rentiership is the revenues or values derived from the control of an asset (Birch, 2020).

Chapter Two: Literature Review

This section includes my project's conceptual framework and a review of relevant academic literature. In the first part of this section, I define artificial intelligence (AI) and review the contributions of Canadian researchers to the field that have led to Canada's position as a global leader in AI research. I continue by discussing the expected societal and economic impacts of the Government of Canada's (GC) investments in the AI sector by reviewing research articles that have examined AI's potential as a general-purpose technology.

I then establish the relevance of examining financial dynamics for understanding the economic geography of Canada's AI ecosystem and review related geographic research on financialization. The following section explores the implications of the financialization of knowledge-intensive technologies such as AI for the economy. I continue by discussing research on global financial networks that Canada's AI ecosystem is part of and finish the section by reviewing research from geographers that have engaged with digital geographies and the place of AI in geographic discussions.

2.1. Artificial Intelligence

Artificial Intelligence encompasses many subfields and diverse applications. Scientists first coined the term artificial intelligence in 1956; however, philosophical and practical discussions about the definition of AI are still ongoing. Stuart and Norvig (2009) organize these definitions into four different categories based on the approach of their developers: thinking humanly, acting humanly, thinking rationally, and acting rationally. In essence, the approaches differ based on what AI is supposed to accomplish.

Alan Turing (1950), for example, developed a test called the imitation game to check a computer's intelligence in which a human interrogator poses some questions to two individuals labeled A and B. One of the participants is a woman, and the other is a man. The interrogator's role is to determine which one is which. If a computer switches with A or B and the interrogator does not notice a difference, the computer passes the Turing test. He designed this test to replace the abstract question of "Can machines think?" and created an operational definition of intelligence that tests "how human" a computer can act. This definition falls under the thinking humanly category of AI definitions. Stuart and Norvig themselves believe the rational agent (acting rationally) approach to defining AI is the best and concentrate on “general principles of rational agents and on components for constructing them”(Stuart & Norvig, 2009, p. 5) in their book.

Recent developments and contemporary discussions around AI technology often involve machine learning which is a capability that an intelligent machine must possess to pass the Turing test or be considered a rational agent. Turing made a case for machine learning by hypothesizing that producing a program that simulates a child’s brain and subjecting it to an appropriate education course should be simpler than simulating an already developed human brain. On a more technical note, Mohri et al. (2018) define machine learning as computational methods that allow agents to improve their performance or make accurate predictions using experience - in which experience is past information that can take the form of electronic data.

What Canadian researchers Hinton et al. (2006) accomplished was developing a greedy[3] fast learning algorithm that could find attributes in deep networks with millions of parameters. It made it easier for machines to learn from and analyze deep, complex multi-layered data. Goodfellow et al. (2016) explain this sort of AI deep learning as an approach in which the computer learns complicated concepts by building them out of simpler ones. This approach allows the AI to perform tasks that we humans can intuitively perform but have difficulty explaining, such as recognizing faces or spoken words. The many layers of simpler concepts that the AI builds upon to understand these more complex concepts are why this method is called deep learning. Deep learning has brought about breakthroughs in processing images, videos, and audio (LeCun et al., 2015), with Canadian researchers continuing to be prominent figures in the advancement of AI through deep learning (e.g., Hinton et al., 2012; Krizhevsky et al., 2012).

2.2. AI as a General Purpose Technology

With a leading position in AI research and development and deep learning, the Government of Canada is now aiming to harness AI’s potential as a general-purpose technology (GPT). GPTs are technologies that can be deployed in many sectors, opening opportunities for

[3] In optimization problems, greedy algorithms always make the choice that looks best at the moment. They make locally optimal choices hoping the choices will leads to globally optimal solutions. (Cormen et al., 2001, p. 370)

innovation and associated with significant growth potential for economies (Bresnahan & Trajtenberg, 1995).

For example, Basu and Fernald (2007) discuss information and communication technology (ICT) as a GPT to explain why total factor productivity (TFP) accelerated in industries using ICT in the United States during the 1990s. TFP is the choice measure of productivity in economic research (Kohli, 2015). Part of their reasoning was that the main feature of a GPT is that it fundamentally changes production processes. Through an empirical research process, they found evidence that supported their hypothesis and argued that complementary investment is vital for realizing the productivity benefits of ICT usage across a range of industries. However, in the period that Basu and Fernald studied, many industries were just beginning to incorporate ICT infrastructure in their workflows; hence, there was an initial period of productivity loss resulting from training the workforce to utilize ICTs and streamline overall processes. The researchers tried to control for this factor but conducting such a massive analysis spanning multiple industries in retrospect is challenging. Nonetheless, the results from their research were well-received, and a takeaway from this project would be that the productivity benefits from a GPT often come after initial losses and that investments play a significant role in unlocking their potential.

Potentially significant but delayed productivity gains and economic growth could also apply to industries that deploy AI. For example, Furman and Seamans (2019) reviewed the evidence of AI's effect on the economy and came to similar conclusions. They also cited researchers who have observed an increase in AI-related investments alongside a growing number of AI startups. In parts of their paper, they cover potential issues in the industry and policies that might address them: for example, large datasets required for training AIs being a barrier of entry for startups, potential platform monopolies, and implications for the labor force. Although it is a useful analysis, Furman and Seamans focus specifically on the USA, which means the applicability of their findings to Canada is unclear.

A report that explored the complications of AI as a GPT with a slightly more technical approach came from Manual Trajtenberg (2018). The report emphasizes the necessity of governments developing innovative strategies for revamping education and personal services in response to the changes AI will bring about as the next GPT; however, what makes the working paper particularly interesting is the distinction it makes between "human-enhancing innovations"

(HEI) and “human-replacing innovations” (HRI). AI-based HEIs augment human capabilities making them carry their tasks more efficiently, while AI-based HRIs would replace humans, substituting for existing employment. Unfortunately, the report, again, is focused on the USA, meaning that its relevance to the Canadian context is debatable

Allan Dafoe (2018) makes a case for researching the effects of AI through an international political economy lens, framing the threat of growing international AI monopolies and the potential appearance of AI mercantilism or AI nationalism as driving research in this area. He argues that countries are competing to build up their exclusive AI national champions, with competition being especially fierce between the US and China. At the same time, he argues that countries like Canada need to evaluate how much of their AI investments they are embedding in their own economies, including the issue of how to retain talent. Overall, while Dafoe aims to provide a comprehensive research agenda on AI governance, it lacks the specifities needed to understand the geographical particularities of AI in the Canadian context

Finally, researchers have examined the intricate international dimensions of AI economics through trade theory. For example, Goldfarb and Trafler (2018) identified four aspects of AI as having a critical role when developing trade policies. First, economies of scale from data, in which access to data provides a positive feedback loop: that is, more data leads to improved predictions/performance, which leads to more customers and data. Second, economies of scale from building AI capabilities which mainly hinge on securing the best AI talent. Third is economies of scope, as in which company can get the most applications out of their AI team. Finally, knowledge externalities, such as where R&D is occurring, the clustering of patents, researchers, Intellectual property, and the like. Geography is an essential factor in all these aspects of AI; for example, access to data is increasingly embedded in defined geographical jurisdictions, companies seek to attract talent to their location or move to where talent is abundant, and financial flows (e.g., investment) cross territorial borders. Goldfarb and Trafler largely ignore these financial dynamics in their model; yet, those dynamics can have significant implications for many parts of their model. It is, therefore, important to examine these financial dynamics to understand the economic geography of AI.

2.3. Financialization

Here, I am going to discuss some of the most important work on financialization that has come out of the social sciences in the last two decades. According to Epstein (2005), "financialization means the increasing role of financial motives, financial markets, financial actors, and financial institutions in the operation of the domestic and international economies" (2005, p. 3). However, this definition can be too broad, especially for the purposes of this research project. Krippner (2005) defines financialization as a "pattern of accumulation in which profit-making occurs increasingly through financial channels rather than through trade and commodity production" (2005, p. 2). In her work, Krippner finds empirical evidence supporting the American economy's financialization after the 1970s. She concedes that her research relies heavily on domestic US data and that the spatial restructuring of economic activity – production occurring abroad while financing occurring predominantly domestically – might be affecting her data.

Geographers have sought to extend the relevance of financialization for understanding economic geography. For example, Pike and Pollard (2010) analyze instances of financialization occurring in the brewing industry and the rise of weather derivative contracts to contribute to the empirical body of the economic geography of financialization research. Their findings demonstrate how financialization represents a new avenue of exploitation (e.g., climate change), creates heightened risk and volatility in contemporary capitalism, and contributes to continuing uneven development and spatial inequalities.

Sarah Hall (2012) reviewed various geographical research that examined how the international financial system affects people's economic and social life and what role space and place have in financial subjectification. Rudnyckyj (2017, p. 272) defines financial subjectification as "the deployment of financial devices to inculcate and elicit subjective dispositions, modes of fiscal being, and courses of economic action." This definition is broad, yet Rudnuckyj uses it to discuss the different strategies the Malaysian state developed to create financial subjects.

Going back to economic geography, a critical conclusion from Hall's report was that geographers had expanded financial subjects to include financial elites as they are not a "geographically homogeneous, pre-existing cadre of actors." This inclusion reemphasizes the importance of analyzing investment sources and their attached motives. In fact, Hall argues that the meso/micro-scale analysis of finance is vital as it demonstrates the uneven production and consumption of it.

One area of research that demonstrates how geography influences financial dynamics is housing and real estate. Geographic research has demonstrated how socio-technical changes and regulatory constructions have turned the built environment into financial assets across the globe. Aalbers (2019) surveyed examples of this work and categorized them based on their primary focus, such as mortgage debt, mortgage securitization, rental housing, housing companies, and commercial real estate. Each section included notable countries or regions of the world that were particularly subject to that form of financialization. Because of the structure and purpose of the paper, there is not enough room for a detailed comparison of the local context each study examined.

However, through a second-hand analysis of research, Fields and Uffer (2016) conducted a comparative study between the rental housing markets of New York and Berlin to specifically explore how each city's local and political-economic context influenced and shaped the financialization trends they experienced. Similar to Sarah Hall (2012), their work challenged the idea that financialization is a homogenous and a-spatial process. Their findings showcased these geographical differences while emphasizing how policy decisions can hasten financialization trends. Even with varying contexts, both cities experienced heightened inequality and worsened housing conditions due to financialization.

As evident from the examples above, the analysis of financialization trends through a geographical lens is necessary. This is particularly relevant for understanding the emergence of new industrial sectors, like AI. While researchers have established the potential of AI as a GPT, it is still a growing field. Scientists continue to develop new applications and research new learning methods; however, unlike the 1980s in which academics and publicly funded institutions were pioneering AI research, it has become increasingly privatized over time as it has been commercialized – and this has significant implications for understanding its geography. Jurowetzki et al. (2021) documented this trend through a comprehensive analysis of bibliographic data. Their findings show that AI researchers, especially those working in deep learning (which Canada is a pioneer in), are highly likely to join industry. They recognize this as a concerning trend as private researchers prioritize commercial interests over socio-economic sustainability and ethical considerations. In fact, there have been instances where companies allegedly ousted AI researchers who voiced ethical concerns that threatened their businesses' commercial interests (Hao, 2020).

2.4. Technoscientific capitalism and rentiership

There are more angles to understanding the ramifications of financialization of AI research. The very bedrock of financial capitalism is the constant search for and the construction of new asset streams (Leyshon & Thrift, 2007). Like any other sector, AI is subject to financial dynamics that aim to create asset streams and extract value from them.

One form of asset that is prominent throughout technoscientific capitalism is knowledge. As noted by Birch (2017b), in 2008 the United Nations revised the System of National Accounts so that it categorized R&D spending as a fixed investment instead of an expenditure. This arrangement effectively extended the boundary of an asset to include knowledge outputs of research activities. Birch's following analysis of the life science industry in the UK – or the biotech industry to be more precise – revealed investment streams that did not necessarily correlate with results produced by or the profitability of biotech startups. He explained this discrepancy in part by utilizing the concepts of assetization and rentiership.

Rentiership or the capture of economic rents is a process in which "value is extracted from economic activity—broadly conceived—as the result of the ownership and control of a particular resource (or asset), primarily because of that resource's inherent or constructed productivity, scarcity, or quality" (Birch, 2020, p. 2). In the case of life sciences, the promise of a new treatment or drug by a startup in the R&D stage could incentivize investors to pour capital into it without showing any results (e.g., products). The infamous case of Theranos, in which a startup claimed to revolutionize blood testing only for its many promises to fall on its face, is a prime example of this process. Theranos raised $724 million without demonstrating any products until the company ceased its operations in 2018, and its CEO and former president became subjects to massive fraud lawsuits (Tun, 2021).

Rentiership reflects a broader shift from ownership to leasing behavior in our increasingly digital economies (Perzanowski & Schultz, 2016). This shift further enables the expansion of monopoly rents, in which the exclusive rights or control over the majority of a resource enables the owner to profit from leasing it and encourages anti-competitive practices in the industry (Purcell et al., 2020). Once an economy becomes reliant on rent-seeking, it might struggle to diversify; for example, Ecuador's reliance on extracting rent from natural resources has been hindering its state-led shift towards a knowledge economy (Purcell et al., 2017).

Within technoscientific capitalism, corporations direct innovation towards capturing and extracting economic rents from socio-spatial relations to the detriment of creating new markets, products, and services (Birch, 2017a). Of particular relevance to this project is how businesses increasingly treat people's personal data as assets, and innovators focus on how to extract value from them (Birch et al., 2020). However, rents do not appear out of thin air, and there are socio-spatial processes that lead to their creation. There is an empirical gap in the analysis of rentiership and the emerging shift of rent-seeking actions in innovation sectors (Birch et al., 2020). As previously established, financialization is not geographically homogenous and it entails geographical specificities, like diverse motives of financial elites in different countries. In the context of this project, I want to examine the AI ecosystem in Canada by analyzing the financial (and other) dynamics in the AI sector, especially the tensions between its embedding in Canada's specific geographical political economy and in the global financial network (GFN).

2.5. Global financial networks

Geographers have approached the definition of GFNs from different angles. Wójcik (2018) builds their definition up from the components that make up GFNs. He defines financial firms as finance and business service (FABS) firms and their affiliated IT service providers. These, together with public financial institutions, are considered financial organizations. The concentration of financial organizations and their activities constitute financial centers. As such, GFNs are networks of FABS that link financial centers, offshore jurisdictions, and financial subjects across the globe. Wójcik and Camilleri (2015) see these financial centers as significant forces of urbanization in China and developing countries, but they are also relevant for countries in the Global North.

For Coe et al. (2014), the building blocks of GFNs are advanced business services (ABS), world cities (WCs), and offshore jurisdictions. World cities have a similar function for Coe et al. to that of financial centers for Wójcik. However, while their definitions are similar, Coe et al. more strongly emphasize GFNs as a way to integrate finance within global production networks (GPNs). They provide two reasons for this: the fundamental role GFNs play in all economic activities within GPNs and the neglect of finance within GPN literature that overlooks financial motives and drivers that increasingly shape GPN structures.

Key to understanding the AI sector is an understanding of the role of intangible assets in these GFNs and GPNs. Durand and Milberg (2020, p. 404) define intangible assets as "nonfinancial assets that lack a physical substance, are nonrival in consumption and are at least partially appropriable," which organizations protect through intellectual property rights (IPR). According to them, monopoly rights over these assets enable the owners to extract different types of rents, such as legal IP rents or data-driven innovation rents in which data access fuels innovation. Durand and Milberg situate these assets along global value chains; yet, for others, like Grabher and van Tuijl (2020), global networks, or to be precise, the GPN approach, seems to not provide the best means to analyse the full extent of digital capitalism geographically.

2.6. Platform capitalism and digital geographies

Grabher and van Tuijl (2020) believe that the rise of digital platforms challenges GPN theories along different axes, requiring some theoretical readjustments. For one, GPNs traditionally frame value as derived from production and focus on "asset-heavy" firms, while platforms such as Uber and Airbnb relinquish ownership (and its associated responsibilities) and instead focus on facilitating access and managing relationships. This observation aligns with Rochet and Tirole's (2003) conceptualization of platforms as two-sided markets: one side is the asset owners, and the other is consumers. Davis and Sinha (2021) undertook a comparative case-study analysis of ride-hailing platforms in Europe, Asia, and the US, arguing that innovation in ICTs alongside nationally specific institutions leads to substantially different organizational forms in the ride-hailing industries of different countries.

Geography has seen a significant digital turn in recent years, with a focus on digital technologies and information as a way to analyze changing geographical political economy (Ash et al., 2016). Jathan Sadowski (2020) views digital platforms as increasingly vital parts of the economic structure of society that represent emerging forms of rentiership, often seeking to extract value from data as assets. In some ways, platforms have become so entangled with urban life that separating them seems impossible (Fields et al., 2020).

Computer software has facilitated the production of relations that connect a diverse set of people and places across the world (Zook & Graham, 2018), as well as infrastructure and assemblages that allow economies to operate without supervision in an automated fashion and from local to global scale inside the material world. As Kitchin & Dodge (2011) note, this creates coded spaces that mirror the spatial structures and interactions of everyday life.

Geographers have been grappling with how to study the spatialities of AI (Walker & Winders, 2021). Some have been calling for a critical inquiry into the socio-spatial impacts of incorporating AI technologies into society and the implications this will have for traditional conceptualizations of space and place within human geography (Alvarez Leon, 2021; Lynch, 2021a, 2021b). Researchers have been trying to place automation into geographic discussions and theorize the effects of robotics on employment (Attoh et al., 2021; Samers, 2021). There are instances of geographers advocating for more widespread usage of AI in geographic disciplines, such as Torrens (2018), who has explored the evolving relationship between AI and behavioral geography and argues that AI can be useful in helping us frame and explore human behaviour and social phenomena.

The advent of AI as a GPT has made the relationship between AI and development the subject of growing debate (McDuie-Ra & Gulson, 2020). While other researchers have examined the global distribution of AI startups (Bessen et al., 2018; Simon, 2019) and AI-related patents (Van Roy et al., 2019), this project represents one of the most extensive multimethod inquiries into the economic geography of a country's AI ecosystem to date.

Chapter Three: Methodology

As I outlined in the literature review, the empirical analysis of financial dynamics through a geographic lens is crucial for understanding the economic geography of AI in Canada. AI as an industry also relies on location-specific resources and factors to thrive; the difference from an extractive industry such as oil is that those factors are not dependant on natural resources. Instead, access to talent, finance, and government policies play a significant role. Therefore, I designed my research project with the hopes of analysing these factors.

In social sciences, when examining contemporary events in which the researcher cannot manipulate the relevant behavior of the study subjects, case studies have an advantage over other research strategies (Yin, 2002). This project has a broad research topic that covers complicated multivariate conditions and relies on multiple sources of evidence. According to Yin (2003), these factors indicate that a case study research is an appropriate form of inquiry for this investigation. The case study of this project is the Canadian AI ecosystem or tech sector and I utilized a mixed-methods approach for analyzing it.

First, I conducted a policy analysis of provincial governments across Canada to understand the jurisdictional context of the research and their plans for the future of the AI ecosystem. Then I constructed a multi-relational database of Canadian AI startups and their investors and analyzed it. This stage provided a snapshot of the current financial state of the AI ecosystem. In the final stage, I interviewed executive and senior-level professionals in the industry to understand the decisions that have led to the AI ecosystem's current state.

In this section of the thesis, I will go over each stage in more detail.

3.1. Stage one: The jurisdictional context of the case study

The first stage of the case study entailed a critical discourse analysis of Canadian policy and government documents relating to the AI sector (Fairclough, 2013). It entailed collecting and analyzing policy literature produced by different levels of the Canadian government and affiliated organizations to understand their roles and plans for developing the AI sector with an additional focus on the jurisdictional borders that configure it. The goal of this stage was to establish the political-economic context to the development of Canada's AI ecosystem.

Notable sources for the literature included the Canadian Institute For Advanced Research (CIFAR), the Canadian Parliament and the House of Commons' online libraries, the Government of Canada's online policy documents, federal budget plans, federal and provincial privacy commissioners, Provincial Government websites across Canada, and the Information and Communications Technology Council.

I carried out the analysis using NVivo, a qualitative data analysis software that enables users to assign codes to parts of the literature and analyze and query those parts together. In addition, NVivo enables users to look for themes and repeated words within the corpus and search the documents for specific terms.

I coded instances of geographic awareness within the policy documents to understand how policymakers geographically conceptualize and situate the AI tech industry in Canada. I took a page out of Birch et al.'s (2014) policy analysis of the European Knowledge-Based Bio-Economy for the discourse analysis. Similar to them, I looked for three types of narratives within the policy documents: descriptive accounts of the threats and opportunities AI presents; normative accounts of necessary or desirable responses to them; and performative accounts of carrying out those responses.

3.2. Stage two: The financial workings of Canada's AI startups

In the literature review, I established the necessity of applying a geographically sensitive analytical framework when studying finance and understanding the contemporary spatio-economic dynamics of the advent of AI as a general-purpose technology (GPT). Canada's position as a global AI power is due to its strong academic institutions and AI-related research networks, and the Government of Canada is trying to leverage that advantage to grow its economy. This strategy, combined with AI's status as a developing technology, mean that AI startups constitute the majority of Canada's AI tech sector. Thus, a financial geography analysis of Canadian AI-focused businesses with particular attention to startups could provide an informative snapshot of the ecosystem's current state.

The data source that I used for the analysis is Crunchbase, a private platform with business information on a range of private and public companies globally. Researchers have used its data to research the potential of AI or, more specifically, deep learning as a GPT (Klinger et al., 2018) and the financial and IP information of innovative startups across different countries

(Breschi et al., 2018). Dalle et al. (2017) released a working paper documenting different economic and managerial research that utilized Crunchbase - the "the premier data asset on the tech/startup world"(Dalle et al., 2017, p. 5).

Crunchbase provides free access to researchers, which I applied for and received. After applying first, they provide researchers with "basic research access," which includes access to their "Open Data Map" and "2013 Snapshot" datasets. The Open Data Map includes information such as the name, a short description, and the location of organizations and people in their database but does not include any financial information. The 2013 Snapshot includes financial data such as funding rounds, Initial public offerings (IPO), and acquisitions in SQL format; however, as apparent from the name, the data is from 2013. In the fast-changing world of tech, especially when researching startups and Canada - which has implemented a new AI strategy since 2017- this data is too old. I communicated this issue with Crunchbase's support team; they evaluated my application in-depth, and after a few days, they provided me with full research access.

Users with full research access can access the data in two ways. One is through a daily CSV Export that includes separate files for companies, people, funding rounds, acquisitions, and IPOs. These CSV files have huge sizes, and without setting them up as a relational database, managing, analyzing, and querying them would prove difficult. Nevertheless, Crunchbase does not optimize the CSV files for being imported into a database, and the process is challenging.

The primary way to access Crunchbase's data with full research access is by utilizing the REST API. An API or application programming interface is a software interface that facilitates communication or data exchange between computer programs as an intermediary. Users have to use the REST API to access all information on Crunchbase. The language with which the API communicates is JSON. JSON (JavaScript Object Notation) is a human-readable lightweight data-interchange format based on the JavaScript programming language. Below I have included a code snippet from a Crunchbase example that searches for companies in Europe with between \$25M- \$100M (USD) in funding from its database.

```json
{
  "field_ids": [
    "identifier",
    "categories",
    "location_identifiers",
    "short_description",
    "rank_org"
  ],
  "order": [
    {
      "field_id": "rank_org",
      "sort": "asc"
    }
  ],
  "query": [
    {
      "type": "predicate",
      "field_id": "funding_total",
      "operator_id": "between",
      "values": [
        {
          "value": 25000000,
          "currency": "usd"
        },
        {
          "value": 100000000,
          "currency": "usd"
        }
      ]
    },
    {
      "type": "predicate",
      "field_id": "location_identifiers",
      "operator_id": "includes",
      "values": [
        "6106f5dc-823e-5da8-40d7-51612c0b2c4e"
      ]
    },
    {
      "type": "predicate",
      "field_id": "facet_ids",
      "operator_id": "includes",
      "values": [
        "company"
      ]
    }
  ],
  "limit": 50
}
```

Figure 3.1. JSON query code snippet

In Figure 3.1, “field_ids” are the information fields that the API will return. The “query” has three sections: the first section narrows the results to entities in the database that have received funding in the specified range, the second section specifies the location for the entities, with “6106f5dc-823e-5da8-40d7-51612c0b2c4e” being the location ID for Europe. In the third section, the query specifies that the entities it is searching for are companies. Besides locations, other identifiers such as entity categories (for example, biotech, AI, geospatial) also have unique identifiers that users can find by interacting with the API and running queries.


```
{
  "count": 20088,
  "entities": [
    {
      "uuid": "0ab984e9-7413-addd-0b09-7fd5fdef4150",
      "properties": {
        "identifier": {
          "permalink": "national-institutes-of-health",
          "image_id": "v1479301412/qdfrsmsuqu8m22jaaoor.png",
          "uuid": "0ab984e9-7413-addd-0b09-7fd5fdef4150",
          "entity_def_id": "organization",
          "value": "National Institutes of Health"
        },
        "short_description": "National Institutes of Health is a biomedical
research facility in the United States that focuses on biomedical and
health-related research.",
        "categories": [
          {
            "entity_def_id": "category",
            "permalink": "biotechnology",
            "uuid": "58842728-7ab9-5bd1-bb67-e8e55f6520a0",
            "value": "Biotechnology"
          },
          {
            "entity_def_id": "category",
            "permalink": "financial-services",
            "uuid": "90b4194f-1d4f-ff5c-d7a6-6b6f32ae4892",
            "value": "Financial Services"
          }
        ],
        "rank_org": 3
      }
    },
    {
      "uuid": "20135206-96eb-8be0-9ac4-670b257e532c",
      "properties": {
        "identifier": {
          "permalink": "stanford-university",
          "image_id": "kgi349quyogvrathgoxw",
          "uuid": "20135206-96eb-8be0-9ac4-670b257e532c",
          "entity_def_id": "organization",
          "value": "Stanford University"
        },
        "short_description": "Stanford University is one of the world's
leading teaching and research universities.",
        "categories": [
          {
            "entity_def_id": "category",
```

```
            "permalink": "biotechnology",
            "uuid": "58842728-7ab9-5bd1-bb67-e8e55f6520a0",
            "value": "Biotechnology"
          },
          {
            "entity_def_id": "category",
            "permalink": "communities",
            "uuid": "bc4ee7e1-d4a1-c228-c551-29d716ba971f",
            "value": "Communities"
          }
        ],
        "rank_org": 241358
      }
    }
  ]
}
```

Figure 3.2. Rest API result script example

Figure 3.2 shows what the API returns for the query in figure 3.1. The API has returned the fields requested in the query. In addition, it has included a unique ID for each entry in the database that is the "*uuid*" field. There is a limit to the number of results the API can return in one request, but it can look for results after a specific entity if the sorting order remains the same. Thus, using the API for large datasets entails running the same query repeatedly with different starting points.

Online converters can produce CSV tables from the API responses; however, if the response files are too large, using Python to extract the results might be necessary; this was the case with my files. The *uuid* returned by the API makes working with SQL and database management programs such as Microsoft Access easier. Working with relational databases requires defining a primary key – a unique value not repeated in the columns – for each data table or datasheet. A foreign key is a column in the datasheet that links another table's data; thus, facilitating querying and building relations in the database. As the uuids are consistent across Crunchbase's data, they make adequate primary and foreign keys.

A way to circumvent the tedious process of communicating with the API is using one of Crunchbases' data subscriptions. The subscription makes querying more straightforward and enables exporting a thousand data points at once. Furthermore, some subscriptions unlock new data, such as IP information. Our project funding from the SSHRC allowed us to gain access to these subscriptions. The drawback is that the results are not optimized for extensive data analysis, lack a unique ID field, and have null values and Unicode unreadable characters. A thorough cleaning of the data was required.

First, I developed a schema (Table 3.1) for the table headers to be consistent and easily readable across all the datasheets.

Table 3.1. Database schema

Abbreviation	Word / Phrase
ACQ	Acquisition / Acquired
AMT	Amount
CNT	Count
Cur	Currency
EF	Equity Funding
F	Funding
FR	Funding Round
HQ	Headquarter
INVS	Investors
LEF	Last Equity Funding
LF	Last Funding
Loc	Location
MR	Money Raised
Org	Organization
Pa	Patents
PRC	Precision
STS	Status
TM	Trademark
Tot	Total
TXN	Transaction
Val	Valuation at

For example, a column header that was previously "Last Equity Funding Amount Currency" would now be LEF_AMT_Cur.

The second cleaning step was getting rid of the unreadable characters. I used the following Excel formula to accomplish this:

```
=SUBSTITUTE(F2,UNICHAR(65533),"!")
```

Figure 3.3. Excel formula for removing unreadable characters

This formula substituted all the unreadable characters with an exclamation mark. As the characters were consistent across all datasheets, this method was reliable and did not require further cleaning afterward. Finally, I used the "=NA()" formula to transform all the blank cells into null cells.

After I had cleaned up the data, I used Excel to filter results in the list of Canadian AI companies I had exported from Crunchbase based on acquisition status. From there, I got the list of all companies that had made acquisitions in Canada. I reuploaded that list into Crunchbase, which matched it to its database, and got their headquarter locations. Now I had four Excel datasheets, the list of investors in Canadian AI companies, the list of Canadian AI companies, the list of all funding rounds related to Canadian AI companies, and the list of companies that made acquisitions of AI startups in Canada.

The next step was to build relations and extract data from the database. For example, we have two separate datasheets containing the location of AI startups and companies that made acquisitions in Canada, and we want to create a new datasheet that includes the name and headquarter location of the acquirers and their acquisitions. Figure 3.4 is the SQL code for this query:

```
SELECT [Canadian AI companies].Org_Name AS [Canadian AI companies_Org_Name],
[Canadian AI companies].HQ_Loc AS [Canadian AI companies_HQ_Loc], [Canadian
AI companies].ACQ_by, [Companies that made acquisitions].Org_Name AS
[Companies that made acquisitions_Org_Name], [Companies that made
acquisitions].HQ_Loc AS [Companies that made acquisitions_HQ_Loc]
FROM [Canadian AI companies] INNER JOIN [Companies that made acquisitions]
ON [Canadian AI companies].[ACQ_by] = [Companies that made
acquisitions].[Org_Name];
```

Figure 3.4. SQL code for acquisition location query

The foreign key in the “Canadian AI companies” datasheet (A) is the “ACQ_by” column, while the primary key in the “Companies that made acquisitions” datasheet (B) is “Org_Name”. The query joins the two datasheets based on these fields, and as a result, all records in A that have a value in their “ACQ_by” field that matches an “Org_name” value in B are queried alongside their names and headquarter locations.

I initially believed I could repeat the same process with some tweaking to join Canadian AI companies and investors in Canadian AI companies based on the funding rounds datasheet. Unfortunately, this was not possible due to multiple factors. First, the funding rounds datasheet lacked reliable, unique columns on which I could base the join. An AI startup can have multiple funding rounds, and the same investor can invest multiple times in one or more startups. Second, each funding round in the datasheet included numerous investors in the same column. It was possible to separate them based on commas which I initially did, but it created a very messy datasheet. The third factor was the sheer number of null values in the data that complicated the query.

SQL is not designed or optimized to run complex queries on dirty data. I realized I needed to implement a reiterative process to extract the results I wanted from the database; thus, I wrote a Python program for this specific progress. There was only one problem that I could not bypass using Python either, and that was how to divide the investment amount in a funding round among the numerous investors listed. Crunchbase does not include data on how much an individual investor contributed to a funding round. Nonetheless, each investor's location is important for my project. As a compromise, I divided the amount raised in the funding rounds equally among all investors. While this did not produce an accurate representation, it was the only solution I could identify, and served as an approximation. Furthermore, this project focuses on the location of investors and not individuals; as a result, there is a degree of abstraction that further reduces the loss of accuracy that comes with dividing the amount raised by the number of investors.

```
getcontext().prec = 4
data_frame = pandas.read_Excel("Datasheets\\FR_Input.xlsx")

biglist = data_frame[['Org_Name','MR_USD','INVS_Names']]
db = {}
for index in biglist.index:
    org_name, MR, investors = biglist.Org_Name[index],
biglist.MR_USD[index], biglist.INVS_Names[index]
    investors_list = [ele.strip() for ele in investors.split(",")]

    share = round(MR / len(investors_list)) # Be aware of accumulative error
    if org_name not in db:
        db[org_name] = {investor: share for investor in investors_list}
    else:
        for investor in investors_list:
            org = db[org_name]
            if investor not in org:
                org[investor] = share
            else:
                org[investor] += share


f = open("output.csv", 'w')
f.write("Org_Name,Investor,MR\n")

for k, v in db.items():
    org = k
    for investor, MR in v.items():
        f.write(','.join((org, investor, str(MR))))
        f.write('\n')

f.close()
```

Figure 3.5. Python code for funding round processing

This algorithm first reads the Org_Name, MR_USD, and INVS_Names from the funding round datasheet and puts them in a list called “biglist”, as such, “biglist” is a list of lists. I separated the investors in each round that were previously in the same field and put them in another list called “investors_list”. Then I created a function called “share” that divides and rounds up the investment amounts based on the number of investors in that round, the length of “investors_list”. If there are too many investor records, as we are rounding up to 4 digits after zero (10000th of a dollar), the accuracy falls, which is why I included a warning for accumulative error in the code as a comment; however, the accuracy is sufficient for our purposes.

To query the data, I defined a dictionary called “db”- short for database. Then, I created a loop. It starts by reading organization names (startups) in the funding rounds. When it encounters a new organization, it creates a dictionary key and inputs the investors and the amount they contributed to the organization in that funding round in the form of another dictionary as its value. If the loop encounters an organization that it had previously seen, it will call up its key and open its investors’ dictionary. Then it will check the investors in the new funding round against the investors in the previous rounds. If the investor is new, it will add it as a new key with its share of the investment as the value. If the investor is already a key in the dictionary, it will add the amount it contributed in the new funding rounds to the amount it had invested in the previous rounds.

After the process, each startup that had received funding (org_name) is a key in the dictionary. The value for that key is another dictionary in which its Investors are the keys, and the amounts they contributed throughout all the funding rounds are the values; thus, we have a dictionary of dictionaries. The last part of the code exports the “db” dictionary into a CSV file. That CSV file is now a replacement for the funding rounds, and it allowed me to define new relationships in the database and make location queries. The rest of the data analysis was routine statistics, filtering, and aggregation using Excel.

3.3. Stage three: The manifestation of rentiership in Canada’s AI startup

It is vital to consider the decisions and rationale that have led to the current spatio-economic state of Canada’s AI ecosystem to understand it comprehensively. While numbers show the directions in which capital flows, they do not explain the reason for these financial flows. I therefore decided to interview executive and senior-level professionals in the industry to analyse those reasons(see Appendix A for the interview questions).

The timing of the interviews coincided with the government-enforced lockdowns in Canada due to the global Covid-19 pandemic. As a result, there was no way to conduct the interviews in person or even by phone. The absence of office phone numbers meant that the only method of contacting prospective interviewees was by email. Consequently, the response rate was lower than anticipated, but given the circumstances and the time restrictions of a Master's thesis, there was no way around this.

Through Crunchbase, I randomly selected 60 AI companies located in Toronto and Montréal that had some sort of activity since 2017 from Crunchbase's database. Then, through email finders and organization websites, I found the email address of more than 80 senior and executive-level professionals working in 55 of them and managed to secure 11 interviews. While the number of interviews was small, each individual was highly knowledgeable and involved in the industry. Furthermore, the purpose of the interviews was to gain supplementary information that would help understand the financial data rather than being a primary source of statistically significant data.

In the end, I had conducted more than 450 minutes of interviews, whose total transcript length exceeded 70,000 words. I analyzed these interviews in Nvivo, focusing on the following main themes: location pros and cons, investment flows, clusters, competition, the effect of location on investment and exit strategies, IP strategies, data policies, and AI ethics.

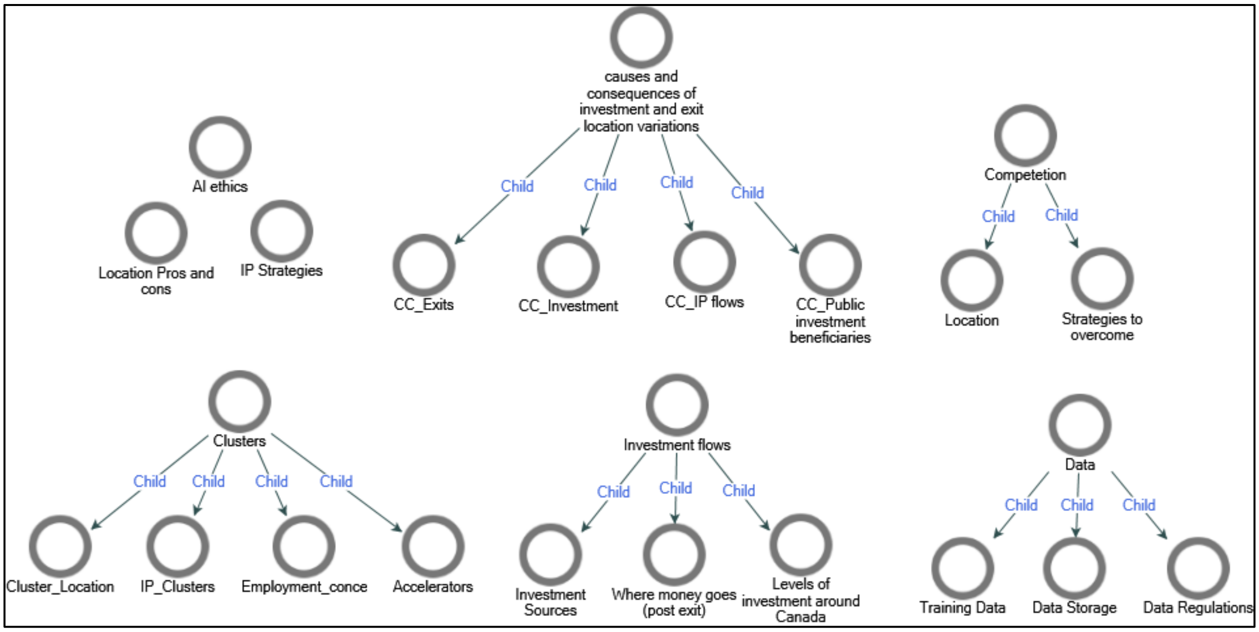

Figure 3.6. Interview analysis project coding map

Regardless of factors that were out of my control, I managed to complete all three stages of the research project. There were interesting results in each stage; however, I believe the cumulation of the three stages has uncovered new insights that would have otherwise remained hidden.

Chapter Four: Policy discourse

One of the catalysts of Canada's growth in AI R&D was a program CIFAR launched in 2004 called "Neural Computation and Adaptive Perception", which aimed to apply our knowledge of the human brain's learning methods to AI (Canadian Institute For Advanced Research, 2019a). CIFAR researchers and their affiliated universities eventually became Canada's leading AI research centers; hence, when the Government of Canada announced the Pan-Canadian AI strategy in 2017, it tasked CIFAR with overseeing it. AI's potential economic impact and its status as an enabling technology mean that effectively utilizing it requires a close partnership among academia, the industry, and the government.

In this section of my thesis, I will explore how the Canadian government and its affiliated entities frame the AI sector, how they envision AI's role in the future of Canada, and what strategies the government is employing to enact those visions. The affiliated entities are organizations like CIFAR that receive public funding and work for the government or the Office of the Privacy Commissioner of Canada (OPC) that operates independently from the government but reports directly to the Parliament. Given how these entities lead some of the government's initiatives and advise policymakers, their discourses contribute to how the public sector views and understands AI.

4.*1. Policy visions*

1. It will be an instrument of economic growth and help tackle various societal challenges

> *"AI (artificial intelligence) stands to increase efficiency, productivity, and competitiveness – factors that are critical to the economic recovery and long-term prosperity of the country"*
>
> (Office of the Privacy Commissioner of Canada, 2020)

According to the OPC (Office of the Privacy Commissioner of Canada, 2020), businesses can reap these potential benefits by producing innovative consumer products or utilizing AI for productivity and workflow improvements in business operations such as resource management or quality assurance. Furthermore, the OPC, alongside CIFAR (2019a) and Global Affairs

Canada (2019), all hail AI's potential to counter social and environmental challenges with the latter introducing AI as a panacea to modern societal challenges:

> *"Artificial intelligence (AI) has the potential to introduce new sources of economic growth, bring significant benefits to our societies and help address some of our most pressing challenges including safeguarding human rights, achieving gender equality, feeding a growing global population, improving the health of our citizens, empowering the elderly and citizens with disabilities, increasing participation in the workforce, countering harmful bias and supporting inclusive societies."*

(Global Affairs Canada, 2019, p. 2)

As the department of Innovation, Science, and Economic Development Canada (ISED) states (2019b), AI can deliver around US$13T in additional global economic output by 2030, and various countries around the globe are trying to gain an advantage in its implementation. In part, this global competition is what fuels the following vision the GC has for AI.

2. Canada must strive to maintain its position as a leader in AI in a competitive world

Like CIFAR, the OPC frames Canada as a leader in AI development (Office of the Privacy Commissioner of Canada, 2020). The ISED claims that leveraging such a technology to gain a competitive advantage in the digital marketplace requires investment in innovation, taking risks, making bets, and adapting quickly to new challenges (Innovation, Science and Economic Development Canada, 2019b). The GC's 2017 Pan-Canadian AI strategy was an effort to utilize Canada's early lead in AI:

> *"To retain and attract top academic talent, and to increase the number of postgraduate trainees and researchers studying artificial intelligence and deep learning, Budget 2017 proposes to provide $125 million to launch a PanCanadian Artificial Intelligence Strategy for research and talent."*

(Department of Finance Canada, 2017, p. 104)

While budget 2017's initial announcement of the AI strategy focused on attracting and retaining talent, the wording around the AI strategy has somewhat shifted over the years.

According to CIFAR (Canadian Institute For Advanced Research, 2019a, p. 3), the goal of the strategy is “to provide deep investment in Canada’s early leadership in machine learning research and training to ensure that we continue to hold our place on the world stage”. There is more emphasis on retaining Canada’s position as an AI leader. Within CIFAR’s annual reports on the strategy’s progress, the emphasis is usually put on the program’s success in attracting top AI researchers to its three main research hubs in Toronto, Edmonton, and Montréal or the increase in the number of startups, businesses, and the amount of public and private investments in the sector.

At the same time, the GC argues that while Canada is an attractive destination for investments, “many Canadian companies believe that to grow, they must relocate outside of Canada” (Department of Finance Canada, 2017, p. 47). While the government argues this issue, there is not much discussion in the documents regarding its causes. However, the GC’s mentioning of the Innovation and Skills Plan as a way to secure investments and help the growth of a broader range of Canadian companies after introducing this problem suggests that the plan might be Canada’s response to this issue.

3. Canada requires top international talent to be competitive in the global digital economy

There are three major Canadian research centers in Canada led by CIFAR program members at the University of Alberta (Richard Sutton), the Université de Montréal (Yoshua Bengio), and the University of Toronto (Geoffrey Hinton). CIFAR stresses these centers play a key role in attracting top students and researchers worldwide through the Pan-Canadian AI strategy, which aligns with its overall mission of bringing together the world’s best researchers (Canadian Institute For Advanced Research, 2019a).

However, incorporating AI into the economy poses new challenges, according to the policy discourse. As Yoshua Bengio states (Standing Committee on Social Affairs, Science and Technology et al., 2017), new jobs created by AI or enhancements made to existing positions through it, demand new skills from employees. Thus, as the ISED puts it, Canada is facing a shortage of skilled workers in multiple sectors related to the digital economy, and businesses need the ability to bring in qualified people from around the globe and incentivize them to remain in Canada(Innovation, Science and Economic Development Canada, 2019b, p. 6). CIFAR repeats this notion:

“Firms and governments need to work together to attract and to retain top talent. This requires addressing issues with immigration agencies to seamlessly facilitate the exchange of talent and cross-border collaboration. Small- and medium-sized enterprises face many barriers to accessing the specialized talent they need to harness new technologies”

(Canadian Institute For Advanced Research, 2020b, p. 13)

Accordingly, the GC argues that for Canadian science and research to be successful, it needs to attract global talent and support its growth and provide researchers with access to cutting-edge research infrastructure. Here, the government is tasked with implementing a system that meets their modern research needs (Department of Finance Canada).

4. Innovation fueled by investments will help the growth of Canadian companies

Throughout budget 2017, the GC accentuated the necessity of venture capital for the growth of Canadian companies due to the funding and expertise it provides.

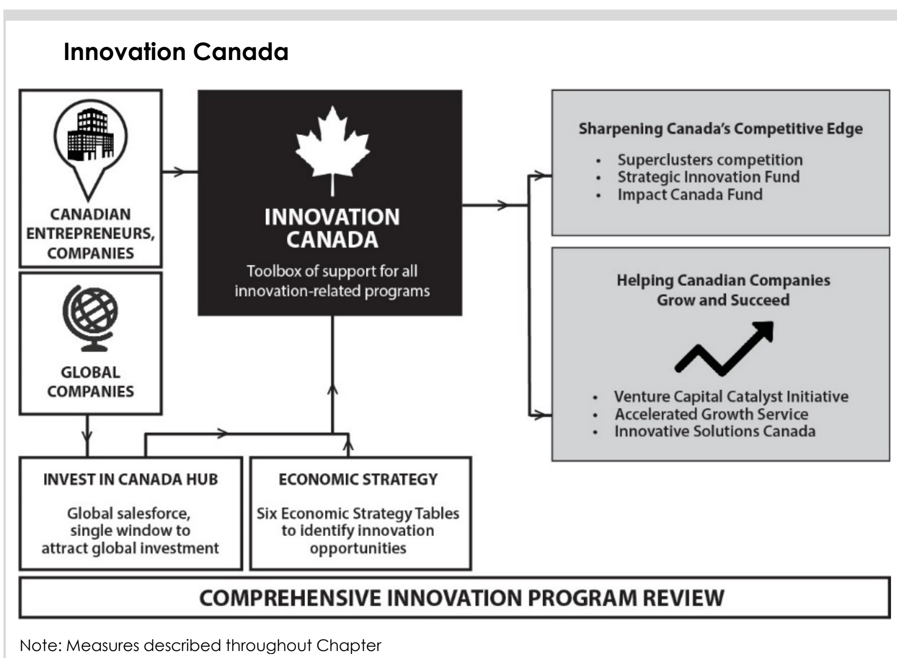

Figure 4.1. Canada’s comprehensive innovation program review

As Figure 4.1 (Department of Finance Canada, 2017, p. 79) shows, streamlining and securing investments is a significant part of the government’s vision for establishing an innovative economy in Canada fueled by startups and superclusters. Global Affairs Canada reiterates, in a 2019 report, that it is necessary to invest in entrepreneurship, research, education, and the labor market to realize the potential of AI technologies (Global Affairs Canada, 2019, p. 2).

There are three other note-worthy investment-related framings inside the budget. One is that the government believes retaining investments is important for building Canada's technology and industrial strength (Department of Finance Canada, 2017, p. 76). The others are that Canada needs to increase access to late-stage venture capital for growing firms and that high-quality business investments can expand the role of Canadian firms in regional and global supply chains (Department of Finance Canada, 2017, p. 47).

5. Canada needs to increase the cooperation between business and academia

According to the ISED (2019a), even though Canada trains Excellent researchers, it does not adequately transition them to the industry in Canada. Furthermore, the ISED argues that despite Canada's geography and trade agreements giving it access to the world's largest consumer market, it fails to produce enough consumer products compared to other global economic powers.

The GC is trying to expand its tech sector and the partnership between academia and the industry by providing funds, tax credits, and access to investment streams, hoping these will increase the number of startups created across the country and the growth of tech superclusters across Canada.

> *"Facilitating greater partnership and mutually beneficial clusters, such as those underway through the Innovation Superclusters Initiative, can help establish connections and build competitiveness in areas where Canada already leads. Working together with government, industry, academia, etc. will help build expertise, attract investment, and involving students through work-integrated learning programs will help build skills"*

(Innovation, Science and Economic Development Canada, 2019b, p. 9)

6. The implementation of AI poses societal and ethical challenges that need to be addressed

Like any other general-purpose technology (GPT), the rapid development and widespread deployment of AI stand to disrupt many areas of society(Trajtenberg, 2018). The GC has addressed parts of these potential disruptions. The OPC (Office of the Privacy Commissioner of Canada, 2020) has expressed concerns relating to privacy rights and believes the federal laws should be updated to ensure the safe consumption and responsible development of AI in the country.

CIFAR (Canadian Institute For Advanced Research, 2019b, p. 6) asserts that governments must develop and enforce relevant anti-trust regulations that ensure market accessibility, minimize the existence of market monopolies, encourage competition, and guarantee equitable access to AI-driven products and services.

> *"Governments and other actors must ensure that productivity gains are equitably distributed. Technological disruption of work may lead to mass unemployment, either temporary or permanent. This could result in more people requiring access to adequate social support"*

(Canadian Institute For Advanced Research, 2020b, p. 13)

The Senate Standing Committee on Social Affairs, Science and Technology (SOCI) (Standing Senate Committee on Social Affairs, Science and Technology et al., 2017, p. 24) established that labour force transitions and new skill requirements at the entry to mid-career levels are other issues that Canada must address as the economy moves towards the digital age.

4.2. Policy strategies

In response to the visions mentioned above, the GC has implemented several strategies over recent years. These strategies loosely fall within three categories.

1. Investing in an innovative economy

The first set of strategies revolve around fulfilling the GC's vision of having a thriving, innovative economy.

> *"In 2016, the Government of Canada set out to develop an ambitious plan for economic growth, creating jobs for Canadians and helping Canadians gain the skills they need to succeed in a competitive global economy. The Innovation and Skills Plan, announced in Budget 2016***,** *takes an integrated, whole-of-government approach that supports firms at all points along the innovation continuum and Canadians at every stage of their lives"*
>
> (Innovation, Science and Economic Development Canada, 2019b, p. 3)

The Innovation and Skills Plan (ISP) was announced in Budget 2016 and launched with Budget 2017. The plan contains several initiatives and aims to make Canada a world-leading center of innovation, create well-paying jobs, and grow Canada's middle class (Department of Finance Canada, 2018, p. 84). For example, The Venture Capital Catalyst Initiative aims to increase the availability of late-stage venture capital to startups in Canada. The ISP initiatives were established in 2017, concurrently with the plan's launch.

Another of these initiatives is The Strategic Innovation Fund. This fund aims to make it easier for businesses to attract high-quality investment, and according to the GC's website (Innovation, Science and Economic Development Canada, 2021f), it has succeeded in providing investment for 96 projects, contributing $4.9B directly and leveraging $52.1B in investments for Canadian businesses, thereby directly creating more 81,000 jobs. In order to qualify for this fund, businesses must make long-term commitments to Canada and collaborate with universities or other businesses on projects inside Canada.

The Impact Canada Initiative enables different departments within the GC to issue challenges to innovators and distribute rewards based on their results. This outcome-based approach aims to accelerate efforts towards solving Canada's big challenges, such as procuring clean energy streams for rural areas or building smart cities in Canada (Department of Finance Canada, 2017, 2018; Impact Canada, 2021).

The Innovative Solutions Canada (ISP) procurement program is another initiative with a challenge-based approach. The difference is that departments partner with early-stage, pre-commercial startups to address the government's needs and even provide funding for proof of feasibility studies. The challenges cover various areas, such as Using AI to better manage space assets or enhancing the safety of vulnerable road users. The program aims to dedicate over $100 million per year for challenges and has awarded more than 170 companies with funding already (Department of Finance Canada, 2018, 2019; Innovation, Science and Economic Development Canada, 2021a).

After launching all these different initiatives, the GC needed to create a single point of contact for Canadian innovators to find and access government programs and services. Therefore, in January of 2018, it launched the Innovation Canada website[4], which acts as a hub connecting Canadian entrepreneurs with the resources they need (Department of Finance Canada, 2018).

One of the most notable ISP initiatives was the Innovation SuperClusters Initiative that included $950 million in investments to a small number of business-led innovation clusters across Canada. This initiative created 5 Superclusters: Digital Technology, Protein Industries, Advanced Manufacturing, Scale AI, and the Ocean supercluster. While most of these superclusters include AI technologies to some extent, the Scale AI supercluster, which is "based in Quebec, spanning the Montréal-Waterloo corridor" (Innovation, Science and Economic Development Canada, 2020c), primarily focuses on funding industry-led projects aimed at adopting and commercializing AI for supply chains, providing financial support to develop AI and digital skills across the country, and financing the growth of AI startups and small to midsize enterprises (SMEs) across Canada.(Scale AI, 2021) Supporting the Scale AI supercluster is meant to be an attempt by the government to bridge the gap between labs and the industry and commercialize AI technologies.

Scale AI has already received $230 million from the Government of Canada and $53 million from the Government of Quebec, and it serves as a co-investment and innovation hub through which the government matches contributions from the private sector (Innovation, Science and Economic Development Canada, 2019a; Scale AI, 2021a). The ISED expects the Scale AI Supercluster to create more than 16,000 jobs and add more than $16.5 billion to Canada's economy over the next 10 years (Innovation, Science and Economic Development Canada, 2020b).

In another effort to attract investments for Canadian business, the GC announced in the 2016 Fall Economic Statement that it would establish an Invest in Canada Hub. This new federal

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[4] Website link: http://innovation.canada.ca/

body is now dedicated to attracting investments from leading global firms for Canadian businesses; thus, bringing fresh capital to the economy (Department of Finance Canada, 2017). Nonetheless, the government is aware of the potential security risks of opening the country to foreign investments. Under the Investment Canada Act**,** "Non-Canadians who acquire control of an existing Canadian business or who wish to establish a new unrelated Canadian business are subject to this Act, and they must submit either a Notification or an Application for Review." (Innovation, Science and Economic Development Canada, 2021c) This Act ensures that the GC does not lose track of acquisitions made by foreign countries.

Predating the ISP and recent surge of initiatives from the GC to fund innovation is one of Canada's most important research and development incentives: the scientific research and experimental development tax credit (SR&ED). The government has allowed scientific research tax deductions since 1944, and over the years, the SR&ED has transformed into the single most extensive federal program that supports business R&D in Canada, providing more than $3 billion in tax incentives to over 20,000 claimants annually (Canada Revenue Agency, 2020).

2. Building a reliable research and IP infrastructure

An innovative economy requires a reliable infrastructure that allows researchers to utilize data and conduct advanced research effectively. Thus, in Budget 2018, the GC announced new investments of $537 million to implement a Digital Research Infrastructure Strategy. There are four key elements to the digital infrastructure strategy, creating a digital network for research and education allowing researchers to share data and collaborate, data management to allow researchers to find and access data, research software to enable researchers to access and use data, and finally providing researchers with advance research computing that involves supercomputers and allows researchers to analyze massive amount of data (Innovation, Science and Economic Development Canada, 2021e).

According to the experts I interviewed, a barrier that startups and SMEs face is that IP management can be a costly and complicated process. Stressing the importance of ideas in the knowledge economy, the government launched the Canadian National Intellectual Property Strategy in budget 2018 (Department of Finance Canada, 2019).

> *"The objectives of the Patent Collective pilot program and of the IP Strategy more broadly are directly aligned with priority areas under the Government of Canada's Innovation and Skills Plan. In particular, it supports companies, investment and growth; for Canadian businesses to grow and create good, well-paying jobs, they need the ability to turn their ideas into new goods and services that can compete in the marketplace"*

(Innovation, Science and Economic Development Canada, 2019c)

The Canadian IP Strategy included multiple initiatives; notable among them are the Patent Collective that provides its members with access to a patent pool and funding for their IP needs, the IP Legal Clinic Program that will support the provision of free or low-cost access to IP advisory services and establish IP programs within Canadian law schools, and the ExploreIP marketplace that will give Canadian businesses and entrepreneurs access to public-sector owned IP available for licensing or sale (Department of Finance Canada, 2018).

3. To bring global talent to Canada

The Government of Canada's original goal behind launching the Pan-Canadian AI strategy was to retain and attract top AI researchers. A key component of this strategy is the National Program of Activities, a series of workshops, training programs, conferences, and other events held by CIFAR to promote collaboration and partnership between AI researchers (Canadian Institute For Advanced Research, 2019a).

The GC has also launched various programs aiming to aid businesses in attracting global AI talent. Canada's Global Skills Strategy announced in 2016 was one of these programs and led to the inception of a two-year pilot project named the Global Talent Stream in 2017. This project allows businesses to recruit foreign nationals to fill in-demand highly-skilled managerial and professional level positions and has a fast processing time of ten business days.

> *"The Global Skills Strategy is helping employers recruit and employ high skilled workers. We are attracting some of the most highly skilled people of the world now through our Global Skills Strategy. There was a time when Canada used to lose its most talented individuals and now we're getting people coming this way because of our immigration system"*

— *The Honourable Ahmed Hussen, Minister of Immigration, Refugees and Citizenship* (Department of Finance Canada, 2019, p. 108)

Due to the success of the Global Talent Stream, the GC proposed to make it a permanent program in Budget 2019. Another program that aims to increase the diversity of Canadian entrepreneurs is Canada's Start-up Visa Program that provides permanent resident immigration status to global entrepreneurs who wish to grow their companies in Canada (Department of Finance Canada, 2018).

4.3. Conventional wisdom in policy documents

Throughout the policy documents, the government repeats certain notions about the AI ecosystem. In this section, I will repeat some of these notions that will be important for the analysis. They reflect the 'conventional' narrative of policymakers in Canada when it comes to their framing of AI as a sector in Canada and the policy frameworks deemed necessary to support and foster the AI sector.

The first comes from CIFAR and is the idea that there are three main hubs in Canada's AI ecosystem: Mila in Montréal, Amii in Edmonton, and the Vector Institute in Toronto. (Canadian Institute For Advanced Research, 2020b) According to CIFAR, the University of Alberta, the Université de Montréal, and the University of Toronto are the centers of these hubs (Canadian Institute For Advanced Research, 2019a), and the collaboration of these universities with other academic institutions, business, government bodies, and non-profit organizations represent the geographical concentrations of AI expertise and economic growth. Inspired by the success of Silicon Valley in California, many governments pursue policies incentivizing geographic clustering (Hospers et al., 2009). Consequently, the GC mentions Silicon Valley as an example of a successful cluster when discussing its supercluster strategy (Innovation, Science and Economic Development Canada, 2021b).

CIFAR's geographic framing is different from ISED's, which claims, "Canada's decades-long commitment to public funding of AI research has paid off, with world-leading and world-recognized hubs of AI research established in Toronto–Waterloo, Montréal, Edmonton, and Vancouver" (Innovation, Science and Economic Development Canada, 2019b, p. 21) The ISED mentions Waterloo and Vancouver alongside Toronto, Montréal, and Edmonton, while CIFAR explicitly believes the latter three to be the leading research hubs.

The ISED also believes that the Scale AI supercluster spanning the “Montréal-Waterloo corridor” is making Canada a global export leader and will allow supply chains to adopt AI and Canada to industrialize and commercialize AI-powered products and services(Innovation, Science and Economic Development Canada, 2020c). What locations fall into the Monreal-Waterloo corridor, and the motivation behind the naming is not clear.

However, the ISED does provide its definition of a supercluster:

> *“Clusters are areas of intense business activity made up of companies, academic institutions and not-for-profit organizations that boost innovation and growth in a particular industry. Silicon Valley is an example of well-known cluster, and there are many more around the world. A Supercluster is a made-in-Canada approach, where existing clusters have been supercharged with up to $950 million in federal government funding, matched dollar-for-dollar by industry.”*
>
> (Innovation, Science and Economic Development Canada, 2021b)

Under the ISED’s framing, the CIFAR AI hubs as well as other concentrations of academic institutions and businesses, are also clusters. The development of high-tech clusters around academic institutions is a common affair, the biotech clusters in the UK (Cooke, 2001) and China’s leading ICT tech cluster in Zhongguancun, Beijing also benefit heavily from the talent and expertise of local universities.

According to the 2020 Annual CIFAR report on the Pan-Canadian AI Strategy, AI startups in Canada raised $658 million in venture capital during 2019. (Canadian Institute For Advanced Research, 2020a) One of those startups was element AI, Co-founded by CIFAR AI research chair Yoshua Bengio. The SOCI reported (Standing Senate Committee on Social Affairs, Science and Technology et al., 2017) that according to its interview with Dr.Bengio, significant investments from federal and provincial governments have led to sizable investments from large international companies such as Google, Microsoft, and Facebook in Canada. He believed that this trend indicates a shift from Canadian companies moving to the US and Europe due to the lack of venture capital availability in Canada. Element AI was one of Canada’s most successfully funded startups and was acquired by a US company in 2020.

CIFAR (2020b) also believes that the US and Canada share the objective of fueling commercialization through innovative research, and the collaboration between industry and research among the two countries is critical to generating economic growth. CIFAR also argues that enabling the quicker transfer of talent between the two countries will boost productivity for both countries.

As previously mentioned, the GC is aware of security risks posed by foreign investments and monitors them through the Investment Canada Act. The 2019-2020 annual Investment Canada Act report (Innovation, Science and Economic Development Canada, 2021c) included these investments and divided them based on sector and originating country. The sectors are manufacturing, wholesale and retail trades, business and services industries, and other services.

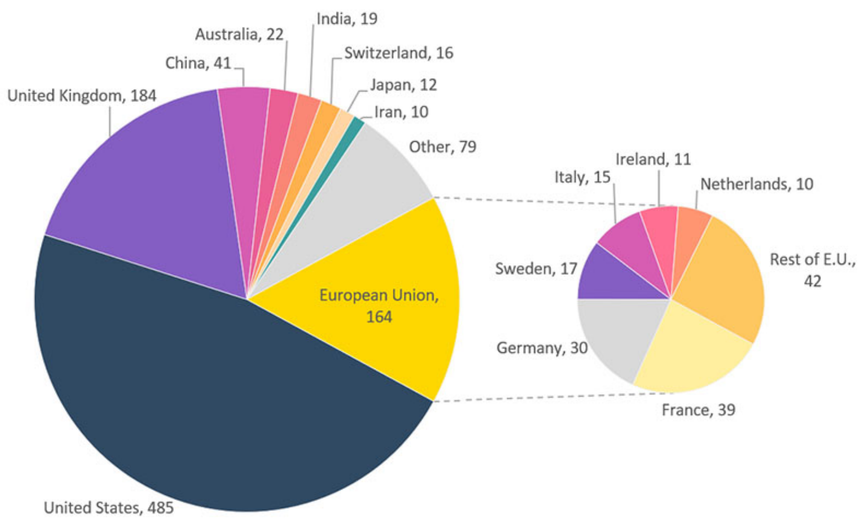

Figure 4.2. Investment by Country or Region of Origin

As Figure 4.2 (Innovation, Science and Economic Development Canada, 2021c) shows, the US makes most of the acquisitions in Canada. The report does not include separate data on the AI tech sector.

Chapter Five: Clusters in Canada's AI ecosystem

This section focuses on the distribution of AI startups across Canada and their effect on intellectual property and employment levels.

Given the GC's emphasis on the role of clusters in realizing Canada's potential as an AI and digital global economic power, it is crucial to examine the concentration of AI startups and companies nationally. There are major debates in economic geography about the role of clusters in economic development (Porter, 2000; Bresnahan et al., 2001; Hospers et al., 2009). Hospers et al. (2009) point that it is not possible to predict the success of high-tech clusters, and even if a cluster succeeds, it might produce limited employment opportunities. On the other hand, Bresnahan et al. (2001) argue that external effects that increase the rate of return to inventions for firms that invent general-purpose technologies lead to the overall economy's growth. Regardless, the consensus appears to be that conditions for the success of regional clusters and their contribution to the economy are not globally homogenous.

In the following sections, I will reiterate the government's viewpoint on the AI ecosystem and compare that with the location and geographical concentration of the ecosystem components according to the empirical data. Then I will analyze the results through the geographical literature and interviews I conducted with senior and executive-level AI professionals in Canada.

5.1. The AI ecosystem's spatial configuration from the government's perspective

CIFAR defines the AI ecosystem as centered on its three main research hubs: Amii in Edmonton, Mila in Montréal, and the Vector Institute in Toronto (Canadian Institute For Advanced Research, 2019a, 2019b, 2020a, 2020b). According to CIFAR, this definition stems from the global prominence of the University of Toronto, University of Alberta, and Université de Montréal in machine learning and the highly-skilled researchers they attract at the heart of these research hubs. Like the biotechnology sector of the UK (Cooke, 2001; Sternberg & Litzenberger, 2004), universities are characterized as key anchors for the AI sector.

The ISED adds Vancouver and Waterloo as prominent research hubs to the discussion (Innovation, Science and Economic Development Canada, 2019b) and highlights the Scale AI Supercluster spanning the Waterloo-Montréal corridor as a major driver of AI industrialization and commercialization in Canada. (Innovation, Science and Economic Development Canada, 2020c)

According to CIFAR (2019a), in addition to Scale AI, Canada's Digital Technology Supercluster in British Columbia and Next Generation Manufacturing Canada (NGen) Supercluster in Ontario also focus on AI. CIFAR mentions Quebec as the location for Scale AI, and Scale AI has received complementary funding from the Government of Quebec that further emphasizes this claim (Scale AI, 2021a). The lack of clarity regarding the location of the supercluster is a common problem of cluster-focused policies, traditionally due to the lack of statistical data (Hospers et al., 2009).

If we go by CIFAR's regional definion of Scale AI, the GC expects it to pioneer the expansion of AI in Canada from a base in Quebec; however, even though Montréal has the highest concentration of AI researchers and students of deep learning in the world, Toronto has the highest concentration of AI startups globally (Invest in Canada, 2017). In that sense, Scale AI is closer to academic and institutional AI researchers than businesses. While the Supercluster's operations are not limited to its local base, the location of its headquarters has a significant impact on the resulting agglomeration economies (Glaeser, 2010), that is, the dynamics that lead to and arise from the clustering of economic activity. For example, there is direct knowledge that is transferred among entrepreneurs working in close proximity, and there is tacit knowledge (Hospers et al., 2009) that comes from observing the success of others. Regional institutions and a localized technology and knowledge base provide access to specialized inputs, employees, and information which are critical for the success of businesses in the cluster (Porter, 2000; Zhou & Xin, 2003). These effects are further ground for clarifying the ambiguity surrounding the spatial configuration of Canada's AI ecosystem.

5.2. The spatial distribution of companies in Canada's AI ecosystem

According to Crunchbase's data from March 2021, there are 913 AI companies with headquarters located in Canada: since then, 19 of them have closed down and 17 of them have had an IPO event.

Table 5.1 shows that a majority of Canadian AI companies are based in Ontario, with Quebec being a distant second and British Columbia having the third-highest number of AI startups and companies in Canada. This compares with the policy discourse outlined above, as well as key policy frameworks – like the Superclusters – that position Montréal as the center of Canadian AI. Furthermore, British Columbia has a higher concentration of AI startups than Alberta, even when normalized by population, despite Albertans having more businesses per population overall.

Table 5.1. The distribution of AI companies across Canada's provinces

Provinces	AI company headquarters: Number	AI company headquarters: %	Number of AI companies per 100000 population (18+ years)[1]	Number of businesses per 1,000 individuals (18+ years)[2]
Ontario	486	53.23%	4.1	38.2
Quebec	176	19.28%	2.5	37.0
British Columbia	144	15.77%	3.4	45.3
Alberta	67	7.34%	1.9	48.3
Nova Scotia	18	1.97%	2.2	37.8
New Brunswick	9	0.99%	1.4	39.9
Manitoba	5	0.55%	0.4	38.0
Newfoundland	5	0.55%	1.1	39.0
Saskatchewan	3	0.33%	0.3	46.3
Canada	**913**	**100%**	**1.6**	**40.4**

Notes: [1]Population data taken from: Statistics Canada. Table 17-10-0005-01 Population estimates on July 1st, by age and sex

[2]Source: Statistics Canada, Table 33-10-0222-01 Canadian Business Counts, with employees, December 2019, Table 17-10-0005-01 — Population estimates on July 1st, by age and sex; and ISED calculation

Ontario aside, Quebec and British Columbia have the highest number of AI businesses, but a larger number of AI businesses per capita suggests that British Columbians are more entrepreneurial than the residents of Quebec and Alberta.

Table 5.2 includes the distribution of AI companies by cities. According to the data, the largest urban AI clusters in Canada are in Toronto, Montréal, and Vancouver. Despite their significance as centres of AI, the GC overlooks Calgary and Ottawa as AI clusters in the policy discourse, even though both cities have a higher concentration of AI startups than Edmonton, which is usually framed as the third centre of the AI sector in Canada.

Table 5.2. The distribution of AI companies across Canadian Cities

		Number of AI startups	
No.	City	Count	%
1	Toronto	337	36.91%
2	Montréal	150	16.43%
3	Vancouver	118	12.92%
4	Ottawa	37	4.05%
5	Calgary	35	3.83%
6	Waterloo	28	3.07%
7	Kitchener	27	2.96%
8	Edmonton	26	2.85%
9	Quebec	15	1.64%
10	Halifax	14	1.53%
11	Mississauga	13	1.42%
12	54 other cities	113	12.38%
	Total	**913**	**100.00%**

In some global rankings, the University of Alberta ranks number one in AI research in Canada, and, as the government repeats numerous times, it is one of Canada's top three AI research hubs; nevertheless, it ranks eighth in Canada in the number of AI startups, perhaps illustrating the difficulty in transferring its talent and research into local businesses.

The approximate number of employee information was available for 815 of the companies in the database. As apparent in Table 4.3, there are currently very few large AI businesses in Canada. Out of these six companies, Splunk, a California-based tech company, acquired the one in British Columbia (Metafor Software), and Microsoft acquired the one in Quebec (Groove). The one in Alberta is a financial institution/fintech company with a dedicated AI research unit that seeks to utilize the technology but does not focus on it.

Table 5.3. Total number of AI employer businesses by business size

	Small AI businesses (1–100 employees)		Medium-sized AI businesses (101–500 employees)		Large AI businesses (501+ employees)		
Province	Number	%	Number	%	Number	%	Total
Ontario	410	50.3%	22	2.7%	3	0.4%	435
Quebec	148	18.2%	7	0.9%	1	0.1%	156
British Columbia	126	15.5%	4	0.5%	1	0.1%	131
Alberta	50	6.1%	5	0.6%	1	0.1%	56
Nova Scotia	17	2.1%	0	0.0%	0	0.0%	17
New Brunswick	8	1.0%	0	0.0%	0	0.0%	8
Manitoba	5	0.6%	0	0.0%	0	0.0%	5
Newfoundland	5	0.6%	0	0.0%	0	0.0%	5
Saskatchewan	2	0.2%	0	0.0%	0	0.0%	2
Canada	**771**	**94.6%**	**38**	**4.7%**	**6**	**0.7%**	**815**

This leaves three large AI-focused businesses in Canada that have not been acquired, all from Toronto, which illustrates the extent to which AI is a nascent sector. Early-stage clusters commonly face challenges such as a lack of infrastructural support (Kasabov, 2011), limited talent with non-technical expertise such as managerial and marketing experts (Bresnahan et al., 2001), and severe competition for talent and market share (Hospers et al., 2009).

5.3. Insights on AI clusters from scientific literature

Research on local cluster development indicates that government policies can reinforce or facilitate the growth of emerging clusters but are typically ineffective at creating new clusters (Porter, 2000; Bresnahan et al., 2001; Hospers et al., 2009). This suggests that the geographic distribution of Canada's AI clusters is not likely to change. Furthermore, AI startups can realize economies of scale from access to data, meaning that the more customers they have, the more data they process, and the more optimized their AI is going to become, which in turn attracts more customers creating a growing positive feedback loop (Goldfarb & Trefler, 2018).

With clusters being magnets for foreign direct investments (Porter, 2000), the financial subjectification of Canada's AI startups is a likely occurrence (Rudnyckyj, 2017). As Fields and Uffer (2016) argue, geographical and political-economic contexts affect the financialization process, and previous research on rentiership (Birch et al., 2014; Birch, 2017b, 2020) has shown that many startups in new knowledge economies do not become standalone companies, but are often acquired by or merge with larger incumbent businesses. To track this possibility in Canada, I have examined the rate at which AI startups have had a successful exit event, such as acquisitions or IPOs that have led to financial liquidity.

Of the 931 startups in the database, 824 had a reliable foundation date. By March 2021, of these 824 companies, 68 had exit events representing 8.25% of them. The percentage of exits per province roughly aligned with the percentage of AI startups in each province, with Ontario accounting for 56% with 38 exits and British Columbia and Quebec both standing at 16% with 11 exits each, followed by 4% in Alberta that came from 3 exits in Calgary and a couple of exits scattered among other provinces. Besides the lack of exits from Edmonton, the number of exits from each province and city does not provide any significant new insights; however, there is a considerable difference in the duration it took for startups to reach that point.

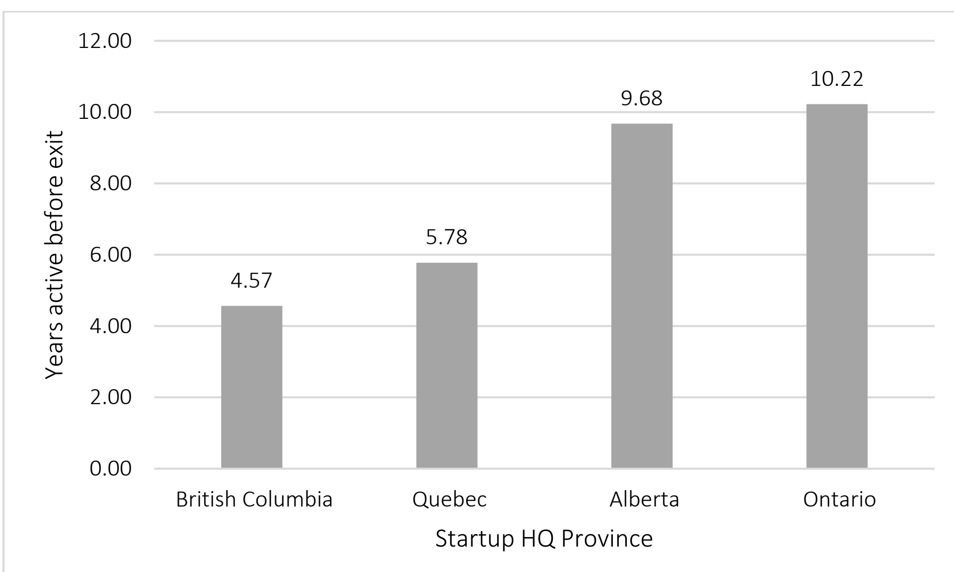

Figure 5.1. Average AI startup activity years before an exit event by province

As shown in Figure 5.1, it took about half the time for startups in British Columbia to have an exit event compared to Ontario. Startups in Quebec were also faster in achieving liquidity events for their investors. Due to the high number of AI startups in Ontario, the average activity years before an exit for startups nationally is about eight years. The average number of years before a startup exits is partly dictated by the industry (Abdullah, 2018); for example, based on Crunchbase's data, the average time it takes for a software as a service (SaaS) startup to exit is nine years globally while it is four years for payment companies and 11 years for hardware companies. AI startups in Canada cover a wide range of industries, so it would be challenging to find the reason behind these trends, especially since the data from Crunchbase does not explicitly indicate the industry of each startup.

The average age of AI startups in Canada is around six years, with AI startups from Ontario, British Columbia, and Quebec being in that range on average. On the other hand, with eight years, Alberta has the highest average AI startup age. This means that there have been fewer new AI startups in Alberta over recent years compared to the other provinces despite one of the National AI Strategies' hubs being located in Edmonton.

5.4. Experts' opinions on the roots of clustering

According to the interviewees, having plentiful access to talent is one of the most significant factors in determining a startup's location. Stephen, the research director at the AI research institute of one of Canada's largest financial institutions, stated that organizations open their research units in cities that have an existing AI ecosystem they can tap into and are rich in AI talent. Indeed, access to skilled labor is considered a critical factor in the development of startups (Bresnahan et al., 2001; Cooke, 2001; Hospers et al., 2009; Porter, 2000). Elaborating on the cities' AI ecosystems, he described the MaRS building in Toronto as "sort of an AI ghetto," noting that the same kind of environment exists in cities like Montréal and Waterloo with top universities.

The interviews further illustrated the difference among local AI ecosystems of different cities. Fredrick is the chief business development officer of a startup in Montréal that utilizes AI for optimization purposes and has raised tens of millions of dollars in funding rounds; when asked if their startup had benefited from the Canadian AI ecosystem, this was his response:

> *"We are a product of it, absolutely, and we continue to benefit from it every day. We are here in Montréal for a reason, for the reasons, Kasra, that you know well, not to say that Waterloo isn't a lovely place or Toronto isn't, but there is a supercluster of AI that was established very successfully years ago [in Montréal and] icon brands like Microsoft and Google have moved into the city, with great fanfare and great investment. There are five to seven universities graduating AI competent engineers at a breakneck speed, such as Concordia and Polytechnique, and we are directly benefiting from some of them. I think the third pillar is the research networks that are well known in the city, including the universities as research partners, who are fueling areas of our development but, most importantly, allowing us to maintain our structure here in Montréal and to help fuel our growth."*

Not only is there ample skilled labor in Montréal, but it is also cheap. One Fintech AI executive from Quebec mentioned that their SR&ED tax credit combined with provincial tax credits from the Government of Quebec meant that they got 70% of their scientific and engineering staff's salary back. These credits significantly reduce the opportunity cost of human capital for AI startups which is the value or profit that could have been gained with the same money and is a driver of entrepreneurship (Bresnahan et al., 2001).

Another interviewee who vouched for Montréal's academic research prominence is Wael. Wael was the chief technology officer and co-founder of a Toronto-based startup that utilized AI in ICT infrastructure automation processes and was acquired for close to $100 million. He believes that:

> *"Montréal can potentially stake a claim that they are a lot stronger when it comes to some of the academic research, and some of the open-source technology. Whereas I think Toronto has a better track record of actually creating successful software companies. And those are very different things."*

Wael is adamant that startups in Montréal struggle to transition from the basic research to innovation, while startups in Toronto and Ottawa are better positioned to develop products, market and sell them, scale-up, and become successful tech companies. This difference could be due to the tacit knowledge transfer within clusters (Hospers et al., 2009); entrepreneurs in a cluster start to emulate other successful entrepreneurs' behavior, which creates a localized atmosphere within the cluster.

Before going back to the talent discussion, it is important to realize that AI companies are not homogeneous. AI is a type of technology or tool that companies use and not an end product per se. Therefore, besides AI engineers and developers, they also need domain experts that specialize in specific industrial applications (e.g. financial experts for fintech companies, geoinformatics specialists for geospatial companies). Steven is the chief marketing officer of a mid-sized biotech AI startup in Toronto, and he states that the high number of PhD biologists in Toronto has given them an advantage in recruiting new staff.

On the other side of this spectrum is Phenomic AI, whose CEO and founder, Sam Cooper, [5] I interviewed for this project. Phenomic AI has publicly raised $11.6 million in its funding rounds and uses AI in attempts to break barriers in current cancer treatments. Sam Cooper stated that, initially, they were developing software for wet labs; however, they decided to move into drug development themselves. Eventually, they opened a branch in Boston, USA, to access its top drug discovery talent and recruit senior drug discovery executives. Life sciences is poised to be Boston's dominant industry, with all three COVID-19 vaccines approved for emergency use in the United States having ties to it (Krisner, 2021). This further reflects a common challenge of new clusters: the lack of managerial experts in the region (Kasabov, 2011).

It is clear that agglomeration economies (Glaeser, 2010) are affecting Canada's AI ecosystem, and the GC's policies for facilitating talent acquisition and subsidizing R&D costs are having an impact on the startups. Canada's AI ecosystem is nascent, and its companies face some of the common challenges of being part of emerging clusters (Kasabov, 2011). In terms of cluster growth, the government's strategy appears to be to provide funding to a geographically ambiguous collection of businesses. The emphasis on superclusters appears to be a marketing strategy, and that is not necessarily an issue; in fact, Hospers et al. (2009) believe that it is best for governments to apply a "do-not-harm" approach to clustering and focus on facilitation, tax reduction and the simplification of regulatory burden for startups. However, this does show the

[5] Mr. Cooper specifically asked not to be anonymized.

government's limited control over the growth of an industry that is poised to become the next GPT (Trajtenberg, 2018).

Chapter Six: Investment flows in Canada's AI ecosystem

While the previous section of the thesis focused on the spatial concentration of the AI sector in Canada, this section is about the investment flows that sustain those clusters. To better understand financing in Canada's AI ecosystem, I examined the levels of investment in these different clusters around Canada, as well as the investment sources and post-exit capital flows.

The Government of Canada is hoping to spur growth in Canada's AI ecosystems by providing public investment supports and incentives to startup founders. These investments are framed as starting a virtuous cycle, reflecting arguments by Mazzucato (2013) and others about the entrepreneurial role of the state in innovation. For example, the CIFAR Pan-Canadian AI strategy included $125 million in funding, but provincial governments across Canada were expected to complement this public investment; Ontario invested $80 million, and Alberta and Quebec invested $100 million in their AI clusters. Matching funding from the private sector (Innovation, Science and Economic Development Canada, 2019a), creating an Investment Hub, and attracting foreign investment (Department of Finance Canada, 2017) are some of the other strategies the GC and Provincial Governments have implemented to finance and support the AI sector.

The AI ecosystem does not simply reflect the location of startups alone. Financial investment is a vital factor in the success of startups, as with other sectors (Jeong et al., 2020), and various locally-specific elements influence the amount of investment available to AI firms. In particular, the sources of investment reveals the extent to which an AI cluster is tied into global 'pipelines' (Bathelt et al., 2002) as well as reflecting a cluster's international reputation. However, just as important as financial inflows is tracking post-exit capital flows, since these geographical flows reveal the ultimate beneficiaries of public investments (e.g., domestic or foreign firms) (Coe et al. 2014), and the extent to which the value produced by public and private financial investment in Canadian AI firms is actually captured and retained within the country or particular city (Birch, 2011).

I will compare the government's policies with the state of the investment flows based on my analysis of Crunchbase's data and take insights from other researchers' work on the financial geography of investments and from the interviews to complement the analysis.

6.1. Levels of investment around Canada

Based on Crunchbase's data, Out of Canada's 913 AI businesses, 340 had publicly announced investments, 293 of which had received equity-free investments. Equity-free investments include Government grants and some startup accelerator programs. These investments enable entrepreneurs to fund their startups without diluting their shares early on. they often reflect public funding by governments, which demonstrates the critical role of the government – and public sector – in supporting hi-tech sectors (Mazzucato, 2013)

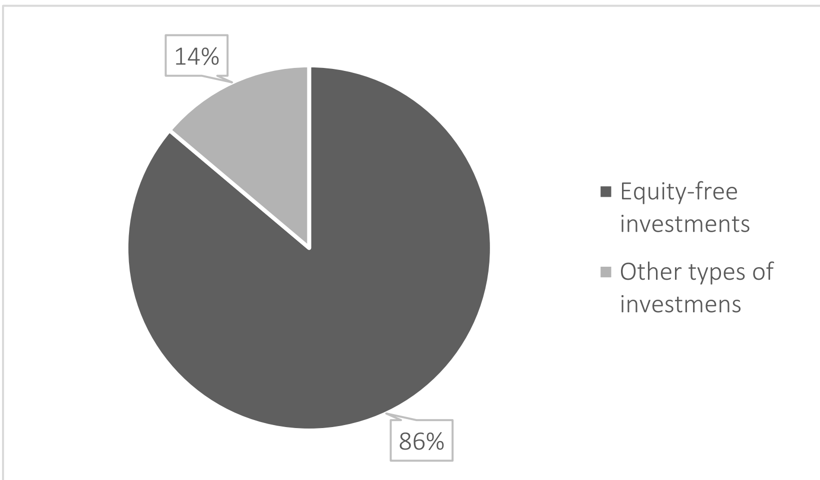

Figure 6.1. Equity-free versus other types of investments in Canada's AI ecosystem

In total, startups in Canada have announced about US$3.4 billion in investments, 86% of which has been equity-free.

As shown in Table 6.1, the provincial distribution of AI startups that have raised funds is similar to the overall provincial distribution of AI startups from Table 5.1. However, startups in Quebec have raised a third of all investments while accounting for about 20 percent of startups. This data suggests that even though there are fewer startups in Quebec, they have benefited from stronger financial inflows relative to startups in other provinces. Comparing this with the provincial distribution of other types of investments in Table 6.2 provides further insights.

Table 6.1. Total funding of Canadian AI startups divided by province

		Total funding			Startups that have raised funds	
Province		**US$**	**%**		**Number**	**%**
Ontario		1,492,591,612.00	43.63%		176	51.76%
Quebec		1,176,809,247.00	34.40%		65	19.12%
British Columbia		491,909,413.00	14.38%		48	14.12%
Alberta		185,193,469.00	5.41%		27	7.94%
New Brunswick		53,542,039.00	1.56%		7	2.06%
Manitoba		10,767,457.00	0.31%		3	0.88%
Nova Scotia		8,983,179.00	0.26%		11	3.24%
Newfoundland		1,461,000.00	0.04%		3	0.88%
Total		**3,421,257,416.00**	**100.0%**		**340**	**100.0%**

Table 6.2. Non-equity-free funding of Canadian AI startups divided by province

		Other types of investments	
Province		**US$**	**% Of Provinces' overall funding**
British Columbia		234,338,279.00	47.64%
Alberta		20,370,474.00	11.00%
Ontario		154,106,522.00	10.32%
Nova Scotia		8,564,04.00	9.53%
New Brunswick		5,025,074.00	9.39%
Newfoundland		86,000.00	5.89%
Quebec		59,139,249.00	5.03%
Manitoba		0.00	0.00%

Notably, about 95% of Quebec's startups' funding is equity-free. The sources of these funds are usually accelerator programs, government funding, academic or research grants, but overall this shows ample public support for the province's startups. On the other hand, only half the funding for startups in British Columbia is equity-free, significantly less than other provinces. Within the policy discourse, British Columbia appears far less frequently than

Ontario, Quebec, or Alberta, and this lack of attention appears to be reflected in the amount of equity-free funding their startups receive. British Columbia aside, startups in other provinces, especially those within hubs in Canada's AI strategy, are receiving hundreds of millions of equity-free funding to grow.

Previous work from McGill University's Centre for Interdisciplinary Research on Montréal (Brandusescu, 2021) estimated the GC's grants and contributions to be C$472 million in Quebec, C$362 millions in British Columbia, and C$196 million in Ontario. These amounts would be 11.8%[6] of the equity-free funding in Ontario and 33.9 of the equity-free funding in Quebec, based on Crunchbase's data; however, for British Columbia, that amount is 113.2% of the announced equity-free fundings. This significant difference does not indicate an error in either study, as Brandusescu (2021) included amounts pledged by the government in their research, whereas my study only includes funding that the startups have actually received.

Accelerator and incubator programs are some potential sources of equity-free funding for startups. Accelerators accept startups on a competitive process and provide services and training to them. Incubator programs match researchers and IP with business professionals and help them launch a startup. At times these programs provide funding based on a future-equity agreement. Negin is the vice president of R&D at a multimillion-dollar AI startup in Montréal, and she has been with her startup since its formation at an incubator program. Fahid is the co-founder and chief technology officer at a Toronto-based startup, and he had this to say about the reason some of these programs provide equity-free services and funding:

> *"I think they have some short-term gains and some long-term gains. Google, will probably mostly focus on the long term, but in the short term, they will give you Cloud Credits, get you hooked up to their ads engine, and in two or three years' time, you are basically in their ecosystem and developing on their ecosystem. In the long term, this is like a breeding ground for investments. They have their investment arm, which is looking for mergers or keeping an eye on startups for acquisitions or investments and this is a place where they can vet out those*

[6] For conversion I used 1 USD = 1.24 CAD

companies and stay part of the ecosystem. These are some of the advantages that they get."

6.2. Investment sources

There are two different data points to analyze here. Crunchbase has the option to create a list of all entities that invested in a location or industry. Looking at this data will reveal the location of investors in Canada's AI sector; however, it does include the amount of their investment.

Table 6.3. Investors in Canada's AI tech sector divided by location

		Investor location	
Country		Number	%
United States		348	44.56%
Canada		322	41.23%
Asia		44	5.63%
Europe		39	4.99%
UK & Australia		25	3.2%
Latin America and the Caribbean		3	0.38%
Total		**781**	**100**

As Table 6.3 highlights, close to 87% of investors are located in North America, and more entities are making significant investments in Canada's AI ecosystem in the states than in Canada itself. However, this does not mean that 44% of investments come from the US. To obtain data on the amount of funding from these sources, I wrote a Python program that separated investors in a given funding round and distributed the investment amount equally among them. While this data does not represent an accurate distribution of investments, it serves as an approximation.

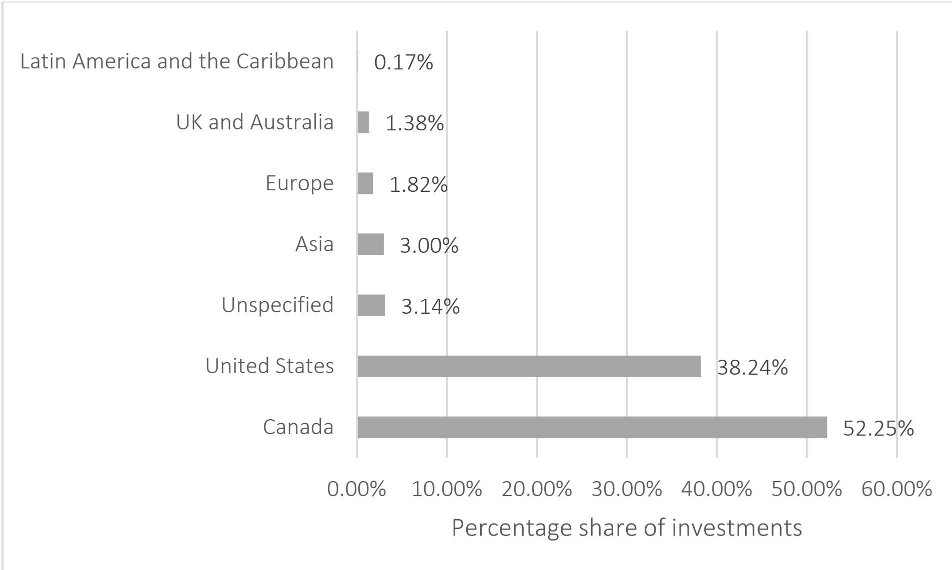

Figure 6.2. Sources of investment in Canada's AI ecosystem

Figure 6.2 displays how investment sources in Canada's AI ecosystem are divided across different regions. Only 52% of the investments come from Canada, including equity-free sources. 3% of investors did not have location data, and the US is by far the biggest source of foreign investment in the AI sector.

Table 6.4. Sources of investments in provinces by investor region/country

Provinces	Canada	United States	Asia	Europe	UK and Australia	Latin America and the Caribbeans	Unspecified	Row Total
Alberta	33.51%	53.73%	0.00%	6.13%	5.91%	0.00%	0.72%	100.00%
British Columbia	41.46%	45.87%	3.00%	0.12%	4.07%	0.00%	5.48%	100.00%
Manitoba	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
New Brunswick	63.66%	29.75%	3.28%	0.00%	0.03%	0.00%	3.28%	100.00%
Newfoundland	41.82%	58.18%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
Nova Scotia	83.39%	5.47%	0.00%	0.00%	0.00%	0.00%	11.13%	100.00%
Ontario	48.37%	40.25%	3.12%	2.54%	1.13%	0.00%	4.58%	100.00%
Quebec	60.74%	32.75%	3.26%	0.92%	0.60%	0.44%	1.30%	100.00%
Canada	52.25%	38.24%	3.00%	1.82%	1.38%	0.17%	3.14%	100.00%

Table 6.4 shows the sources of investment in each province. In Ontario, British Columbia, Manitoba, and Newfoundland, startups have received more money from US investors than Canadian investors. Among the four provinces with the highest concentration of startups, Quebec is the only province raising more money in Canada than foreign investors. Quebec also appears to be the only province to receive funding from Latin America and the Caribbean.

Table 6.5. Investments from countries divided by destination

Country	Toronto	Montréal	Quebec city	Vancouver	Kitchener	Ottawa	Edmonton	Calgary	Waterloo	other
Canada	27.91%	33.33%	12.44%	6.47%	6.99%	3.25%	2.60%	0.64%	0.75%	5.62%
United States	32.40%	19.58%	14.40%	9.61%	3.66%	8.97%	4.61%	2.48%	0.68%	3.60%
South Korea	8.14%	85.75%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	6.11%	0.00%
United Kingdom	27.75%	21.16%	0.00%	24.55%	0.00%	0.00%	24.92%	1.61%	0.00%	0.00%
China	92.35%	0.00%	0.00%	0.00%	7.65%	0.00%	0.00%	0.00%	0.00%	0.00%
Switzerland	0.00%	0.85%	0.00%	0.00%	99.15%	0.00%	0.00%	0.00%	0.00%	0.00%
Japan	1.97%	65.23%	0.00%	30.53%	2.27%	0.00%	0.00%	0.00%	0.00%	0.00%
Germany	20.25%	34.70%	0.00%	0.00%	0.00%	0.00%	0.00%	45.05%	0.00%	0.00%
Other countries	34.05%	21.78%	4.78%	11.94%	5.32%	0.00%	0.00%	7.99%	0.15%	14.01%
Unspecified	47.94%	15.81%	0.00%	11.88%	6.55%	1.54%	1.16%	0.00%	8.38%	6.74%
Grand Total	30.35%	27.40%	12.08%	8.03%	6.21%	5.18%	3.44%	1.61%	0.98%	4.73%

While Table 6.4 shows where investments in each province come from, Table 6.5 shows cities preferred as investment destinations divided by investor country. Overall, Toronto is the city that is the destination of most investments with 30.35%. Montréal is the second destination, with 27.40%; however, it attracts the most Canadian investors, with a third of all Canadian capital flowing to it. Quebec city has attracted more investment than Vancouver and Waterloo because it is home to Coveo, one of Canada's biggest and most successful AI companies that has raised about $340 million in investment.

The countries in Table 6.5 are the top 8 sources of investment in Canada's AI ecosystem. US-based investors appear to prefer Toronto, while UK investors have invested roughly equally in different AI clusters across Canada. Additionally, 92% of investments from China have gone to Toronto.

Wael believes that Chinese investments in Toronto are driven by Li Ka-Shing, the Hong Kong billionaire and business magnate's presence. He added :

> *"The Chinese connection is a very very Toronto thing, you know, and Mr. Lee's evergreen fund called horizons, they invest in a lot of Toronto companies and a lot of game companies, and they see I think for them they see Canada as like an under represented player in the innovation space, so that is why they have kind of built a presence here"*

There was also a possible explanation as to why Canadian investors prefer Montréal to Toronto in the interviews. Daemon is the CEO and founder of a Montréal-based AI company. Before founding the startup, he was already a very successful businessperson in the Canadian technology and computer sector, and his startup focuses on an aspect of AI technology that he expects will yield profits in the long term. His startup has successfully raised a couple of million dollars; however, all of it from outside of Canada:

> *"Technology here in Canada is mostly like apps people have on iPhones right or something like that. Things that get you user numbers within a year, and they're looking at three to five year return on investment. We're technology that is on the 10 to 15 year scale so it's extremely difficult to find funding for that because most investors don't get it. What was interesting is at some point I was so frustrated by just not having results, I started to ask question just in the beginning, which is what is your horizon of return on investment. Anyone who is answering me under 10 years I was hanging up or just basically called it quits the polite way right. And let me tell you there is no one in Canada that was in a 10 year horizon while in Silicon Valley there were plenty people who had kind of long history."*

Daemon believes the issue is that the biggest investment ecosystem in Canada is energy, and there have not been enough value-generating exits in the Canadian tech sector that generate wealth and incentivize investors. So, even though Daemon's startup is based in Montréal, it struggled to attract investments in Canada. Figure 5.1 showed that startups in Quebec had liquidity events faster than those in Ontario. Daemon's statements indicate that Canadian investors prefer short-term-focused investments, and Table 6.5 illustrates that Montréal is the number one destination for Canadian AI investments. Due to tacit and direct knowledge transfers within clusters, this can have an accumulative effect meaning that startups in Montréal will potentially focus on short-term-focused business plans to emulate the success of other businesses in the sector, diminishing the diversity of services and growth potential of the cluster (Bresnahan et al., 2001; Hospers et al., 2009). This could explain why startups in Quebec have faster exit events on average.

There are other differences between Canadian and US investors. Nadeem is the head of business development at a Montréal-Based AI startup; here is his statement regarding the difference between Canadian and US investors:

> *"One main difference between Canadian and American VCs is risk. The way Canadian VCs, and Canadians in general, are a little bit more risk-averse than Americans. A perfect example is when you are growing as a startup. When you go to the US to raise money, especially early on, all they care about is your user growth, that's what they look at, that's the metric that matters to them more than revenue or your MRR monthly recurring revenue. In Canada, that might be important, but I also find revenue plays a role, and because we are a little bit more risk-averse, they want to also see a path to revenue, not just user growth, to make sure that they are making the correct decision"*

This sentiment is shared by some of the other entrepreneurs I interviewed. Fahid says:

> *"Investors in Canada and Europe are a lot more traditional, for sure. So, they will go off on traditional metrics such as revenue, number of customers, and those sort of things, patents, etc. Investors in the US are very different. So, they will go a lot more on like traction; they don't really worry about revenue as much. They*

don't worry about patents, and stuff. Rarely Do US investors ask if you have a patent in place. That is a question you regularly get from Canadian investors. US investors just care about traction, how many users do you have, how much are you growing your user base. Maybe the second thing is revenue, but again, as long as you can show traction they are willing to work with you to grow that revenue and monetize that. I would always hear like there is no change or difference in like investor perspective, between US and Canadian investors, but it cannot be any further from the truth that is absolutely how it works".

Both Nadeem and Fahid's startups have investments from Canada and the US; however, their top investors come from the US. This represents a cycle in which having to produce revenue or profits forces startups to either dilute their shares with US investors making it more challenging to maintain their Canadian identity or prioritize short-term success, resulting in fewer successful large exit events and less wealth and incentive for Canadian investors.

Startups that do succeed in scaling up face a similar challenge in securing late-stage venture capital, with a 2020 report from the ISED (Innovation, Science and Economic Development Canada, 2020a) showing that the majority of investments above $20 million in Canadian companies come from large US funds with the ultimate goal of selling the company as part of their portfolio further down the line to another US financial sponsor. In that sense, the pioneers of Canada's next GPT have become financial subjects of foreign investors, experiencing heightened risk and volatility for their development (Pike & Pollard, 2010). The GC appears to be at least partially aware of these risks as a 2021 renewal of the Venture Capital Catalyst Initiative from 2017 seeks to increase the availability of late-stage venture capital for Canadian firms while explicitly emphasizing the "enhancement of Canadian geographic focus" within the initiative (Innovation, Science and Economic Development Canada, 2021d).

6.3. Post-exit capital flows

The previous two sections covered levels and sources of investment across Canada, and this section is about the ultimate destination of these investments. As stated previously, according to Crunchbase's data, out of the 913 AI companies with headquarters based in Canada, 19 had closed down, and 17 had gone public. Additionally, 51 of them have been acquired, which is about 5.6 percent of all the startups. The Investment Canada Act established in 1985 has been the government's way of overseeing these acquisitions across Canada's primary industry sectors. However, it neither compares it with acquisitions made by Canadian companies nor does its report data on the AI sector individually.

Table 6.6. AI startups acquired in Canada divided by country of acquiring company

	Acquisitions in the AI ecosystem	
Country of acquiring company	**Number**	**%**
Canada	19	37.25%
New Zealand	1	1.96%
Philippines	1	1.96%
United Kingdom	1	1.96%
United States	29	56.86%
Total	**51**	**100.00%**

US companies account for 56% of all acquisitions in Canada's AI ecosystem. This means more Canadian AI companies, along with their IPs and public investments, have ended up in the US than gone public. This figure does not include startups that have moved to the US throughout the years. Sorting these companies by their total amount of funding reveals that 6 of the ten startups with the most funding have been acquired by US companies and one by a UK company. The other three stayed in Canada; however, this data shows that the number and quality of startups leaving Canada is high.

These results reiterate Allan Dafoe's (2018) point that countries like Canada have to reevaluate how much of their AI investments they are internalizing. CIFAR states in its 2020 report that $658 million in venture capital funding went to Canadian AI startups in 2019, a 49% year-over-year increase (Canadian Institute For Advanced Research, 2020a, p. 5). This is the same amount my data shows as well; notably, $200 million of this amount was raised by Element AI, a Montréal-based AI startup. This is the same startup whose co-founder Yoshua Bengio said this:

> *"Significant federal and provincial government investments have attracted further investments from large international companies including Google, Microsoft,*

> *Facebook and others. As he observed, this investment marks a change that signals companies coming to invest in Canada rather than the usual situation where Canadian startups have gone to the US and Europe due to a lack of venture capital in Canada."*

(Standing Senate Committee on Social Affairs, Science and Technology et al., 2017, p. 31)

In November 2020, Element AI was acquired by ServiceNow, a US California-based tech company. Setting aside various tax credits, benefits, and funds, Element AI most likely received over the years from the Canadian government, in 2018, it directly received a $5 million loan from the GC to grow (Galang, 2018). The startup had raised at least $275.5 million, and while the equal division of its funding among the investors show 56% of it coming from public and private Canadian investors, the actual number is likely higher due to the lead investor of its biggest funding round ($200 million) being a Canadian private fund. The case of Element AI is an example of public and private Canadian investments ultimately leaving the country. All the talent, patents, and AI capabilities are now owned by an American company that may or may not continue parts of its operation in Canada.

Three founders of AI startups said during my interviews with them that they would prefer to either go public or get acquired by a Canadian company to strengthen the Canadian tech ecosystem. Nonetheless, they were adamant that it depends on the market, and sometimes they do not have the luxury of choice. The most common benefit the startup executives mentioned from being based in Canada was doing research cheaply. This means that while startups are in the R&D stage, they want to maintain their Canadian identity, but once they scale up and commercialize, those benefits become less important. Besides a patriotic sense of duty to Canada, none of the founders mentioned a specific reason why they would prefer to become acquired by a Canadian company. The same holds for going public that besides maintaining their independence and contributing to Canada's tech sector, they did not bring up an incentive for liquidating by going public. Neither did I find specific strategies regarding these issues in the policy documents.

Chapter Seven: Conclusion & Policy implications

This section covers policy implications for the Government of Canada based on the research results and the interviews with the AI industry professionals. The main topics of discussion in it are AI clusters and financial flows.

7.1. AI Clusters

As the data indicated, most AI startups in Canada are located in six cities: Toronto, Montréal, Vancouver, Waterloo, Calgary, and Ottawa. The interviews indicate that the main reason for this concentration is the talent and expertise the major universities in these cities provide. The GC has been clear that promoting AI technology is part of its policy vision for the future and this promotion will inevitably create significant societal challenges, especially for the workforce. The current state of the AI ecosystem's development means that these major cities will continue to lead Canada's AI ecosystem. The way AI technology scales from access to data and talent and the clustering of its knowledge externalities (Goldfarb & Trefler, 2018) suggests that its economic benefits will not trickle down to the cities in its periphery and will continue to contribute to uneven development and spatial inequalities (Pike & Pollard, 2010).

The data also showed that British Columbia and Vancouver rival Ontario and Quebec in the race to develop AI expertise while often being omitted from the discussion around the AI ecosystem in government reports. The AI hub in Edmonton does not appear to significantly impact the growth of AI startups in the city either. In general, the GC's geographic framing of Canada's AI ecosystem is ambiguous. There are established AI clusters in Canada, and their development is being affected by agglomeration economies (Glaeser, 2010); however, the government's influence is limited in determining their growth trajectory. Nonetheless, the government has been successful in reducing the opportunity costs of human capital (Bresnahan et al., 2001).

Finally, the presence of foreign incubator and accelerator programs in the industry is like a double-edged sword. While it is true that they provide training, networks, and services to startups, they also make startups dependent on their infrastructure and scout startups with potential for early acquisitions.

On the other hand, the interviewees generally praised the incubator programs run by the GC or universities that combined IP with researchers and business professionals and believed them to be somewhat effective at creating an entrepreneurial culture in the AI ecosystem. However, according to the interviews, most AI solutions are open source nowadays, and the way the solution is implemented and the data it feeds on are the most critical factors in determining its success. Some of the startups had benefited from finding industry partners that assisted with the implementation; for example, if an AI program runs on a specific type of hardware, directly cooperating with the hardware producer can vastly optimize its implementation.

Another way for startups to gain an advantage is gaining access to primary and better data sources that the government has been trying to provide to startups through the Digital Research Infrastructure Strategy. Through this strategy that was announced in Budget 2018, the government committed $572.5 million to develop a research infrastructure that provides better access to data, research software, computing resources, and networks to researchers working with big data.

7.2. Financial flows

About 38% of investments in the AI sector come from the US investors and 52% come from Canadian investors. Interviewees expressed concern about the lack of Canadian venture capital for startups with long-term prospects and provided various reasons why they seek US investors. One of the reasons shared among the startups was that the tech market in Canada is limited; therefore, they seek investors in target markets that can help them create connections and grow. Many startups provide business-to-business (b2b) products and services and do not directly engage with consumers. The limited market in Canada presents a challenge for the growth of these b2b startups. This is what one of the interviewees, Lucita, the founder and president of a Canadian health-tech AI startup, expressed regarding this issue:

> *"We have to educate around new technologies, not just AI, a lot of types of technologies. This is a huge barrier right now, that the market is not educated. It's hard, it's hard to grow, or implement these types of technologies."*

The lack of a local consumer market stunts the growth of startups in Canada and forces them to look for connections to enter foreign markets. Moreover, this issue illustrates how much the Canadian AI sector is dependent on foreign countries.

There are other dynamics at play as well; one of the interviewees, Travis, the founder and COO of a successful Canadian fintech AI startup, said that being able to "demonstrate that you are more than a regional player or that you can garner more than regional interest" helps increase the valuation of the company at exit. Other interviewees pointed out that being affiliated with certain US companies or having investors from Silicon Valley makes securing investments in Canada easier for startups.

An important issue to examine further is that with less than 2% of Canadian AI startups going public and about 60% of acquisitions being done by foreign companies, public investments in Canada's AI ecosystem do not appear to return to Canada. Other researchers had already pointed out that, in some cases, public investments in the AI sector went to giant US corporations after they acquired a Canadian startup (Brandusescu, 2021), and this research further elaborates that point and shows that this is a reoccurring phenomenon.

7.3. Conclusion

The Pan-Canadian National AI Strategy focuses on attracting AI talent to its hubs located in Edmonton, Montréal, and Toronto, and there is little discussion in the policy documents and reports related to the strategy on distributing or directing its benefits among different provinces in Canada. The analysis of AI startups in Edmonton implies that the flow of AI researchers to its research hub has not increased the number of AI businesses in the city, which indicates that local access to AI talent will not organically create more businesses. In fact, British Columbia has more AI businesses per capita than both Quebec and Alberta, even though it does not host a national AI research hub, and its startups have had less equity-free funding proportionally than startups in other provinces in Canada.

Even though there is a plethora of discourse surrounding AI talent drain from Canada to the US in the policy documents, there is no concrete strategy focusing on retaining or transitioning the AI talent to the industry. A critical issue the interviews highlighted is that in addition to AI researchers, there is a need for senior managers and executives and other industry professionals that can utilize AI technologies in various sectors such as health, transportation, or energy. The lack of a greater tech ecosystem within which the AI startups can operate is a barrier to their growth.

One of the most significant strategies that the GC has implemented to encourage the growth of its tech industry is the Innovation Superclusters Initiative. Even though the government frames the whole strategy around promoting the development of specialized regional tech clusters, it is entirely ambiguous about its geographic location. For example, the ISED claims that the Scale AI supercluster spans the Montréal-Waterloo corridor but never defines or justifies this geographic framing. This ambiguity suggests that the GC's usage of the term "supercluster" is primarily for marketing purposes. Consequently, tracing any potential future local economic developments back to the initiative will be difficult.

While the location of the GC's supported superclusters is unclear, there are distinct AI clusters operating across Canada, with the clusters in Toronto, Montréal, and Vancouver being the most prominent. AI startups in Vancouver appear to have less access to equity-free funding, while startups in Montréal have benefited from equity-free funding the most. According to the interviews, Canadian investors are more risk-averse and prefer investments that rapidly yield profits. Montréal is the choice destination for Canadian investments, and the average time before an exit event for its startups is indeed low. This could be due to tacit and explicit knowledge transfers within the cluster and potentially indicates the emergence of a trend in which startups in the city prioritize short-term-oriented projects and plans to attract investments, subsequently affecting the growth and innovation dynamics of the cluster.

Geographically tracing the incoming investment flows into the Canadian AI ecosystem highlights the reliance of Canadian startups on venture capital from the US. With 38% of the investments coming from the US, the AI ecosystem is especially susceptible to US foreign policy. This dependency, coupled with the much larger foreign markets that Canadian AI businesses have to serve, makes it more difficult for them to maintain their Canadian integrity and can partly explain why US companies make 60 percent of all acquisitions in the sector.

While the government has been successful in facilitating the growth of AI startups in Canada by providing significant R&D tax benefits and expediting talent acquisitions, this project has highlighted some of the issues and threats the Canadian AI ecosystem faces that, if left unaddressed, could have significant implications for its development and success.

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Appendices

Appendix A: Interview Questions

1. *General Information*

- What is your role in your organization?
- What is your organization's involvement in your sector?

2. *Innovation-Finance Dynamics*

We are interested in the innovation-finance dynamics in your sector:

- What are the main innovation strategies in your sector?
- What are the main business models in your sector?
- What are the main forms of financing in your sector?
- What is the relationship between these innovation strategies, business models, and financing in your sector?

3. *Value Creation*

We want to try and get at how value is created or capture in your business:

- What is the societal and/or technological value of your business?
- How are you creating or capturing economic value from your business?
- How do you realize economic value?
- How does this focus on economic value shape your innovation and business strategies?

4. *Markets & Competition*

We want to get a sense of the competitive imperatives and pressures in your sector:

- Is your sector facing a range of new competitive pressures?
- What sorts of strategies do the most successful firms in your sector deploy in response to competitive pressures?
- How have these strategies changed over time?

- What sorts of competitive pressures do you see emerging in your sector in the next few years?

5. Problems You Face

We want to understand problems your sector faces in creating or capturing value from your business and responding to competitive pressures:

- How do you protect the economic value you create or capture (e.g. intellectual property rights, standards)?
- How does domestic and international competition impact the economic value you create or capture?
- How do domestic and international regulations impact the economic value you create or capture?
- What are the limits and barriers in financing your business?