Boosting Competitiveness of Canadian Businesses: Clearing a Path to Wide-scale AI Adoption

Literature Review

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INTRODUCTION

Firms that integrate artificial intelligence (AI) into their existing business activities can improve their competitiveness, innovation performance, and prosperity. Yet, despite these potential benefits, and despite Canada's robust ecosystem of fundamental research on AI, Canadian firms lag global peers in using AI to support and enhance their businesses. Why are Canadian firms hesitating or struggling to adopt AI, and what can help them improve?

A careful review of existing literature and data reveals a range of barriers and resource gaps—related to infrastructure, financing, cultural and organizational structures, and skills and knowledge. Talent, in particular, is a predominant theme that cuts across all AI adoption barriers, as a precondition for successful AI adoption.

Canadian firms that want to adopt AI often find that they lack access to the talent they need to do so effectively. Addressing this talent gap is essential if Canada wants to overcome barriers to AI adoption and see its benefits manifest throughout the economy. This paper makes a contribution to improving AI adoption by examining what is known about AI's potential economic benefits, the state of AI adoption in Canada and globally, reasons for lagging adoption among Canadian firms and, critically, the kinds of technical, managerial, and translation talent needed for successful AI adoption.

In particular, this paper summarizes key insights and themes from existing literature on:

+ The productivity opportunities and investment challenges AI presents to Canadian firms;
+ Current AI adoption trends and returns;
+ The most common barriers to firm-level AI adoption;
+ Parallels between AI and historic general purpose technology (GPT) adoption trends and barriers; and
+ The core, complementary components needed for successful firm-level AI adoption.

AI: OPPORTUNITIES AND CHALLENGES

Canada's early efforts to position itself as a leader in AI have centered primarily on research and development supported by federal and provincial governments for pioneering academics in areas such as machine learning. To date, these efforts have facilitated critical breakthroughs and supported the education and training of future AI researchers.

According to a recent study, Canada is home to the third-largest concentration of AI experts in the world (Gagné, 2018). This critical mass of pioneers has helped Canada attract a number of global technology companies such as Facebook, NVIDIA, Samsung, and Uber to open up AI research labs in Montreal, Toronto and Edmonton, and enabled Toronto to generate one of the highest concentrations of AI startups in the world (Silcoff, 2018; Invest in Canada, n.d).

However, AI adoption by existing firms and diffusion across the economy is weak. Recent studies have shown that despite the evidence of its transformative potential, very few Canadian businesses are investing in, and using, AI-based technologies and applications (Bérubé et al., 2018). While not every firm will have a business case suitable for AI—due to the lack of data, or product or service relevance—this rapidly developing technology is widely applicable, and businesses across industries are under growing pressure to formulate a strategic approach to adoption.

For the companies that do make investments in AI, most do not make it past initial experimentation, and therefore miss out on unlocking real value (Deloitte, 2018). Achieving productivity gains from AI depends on full implementation and operation at the firm level.

Based on a review and analysis of existing literature, this paper outlines current trends in AI adoption, identifies barriers, and articulates what is known about specific labour and capital preconditions for effective AI adoption. A prominent and recurring theme is talent. For firms to successfully adopt AI and derive benefits, they need access to people with a range of both specialist and generalist skills - including technical, managerial, and translation skills and knowledge. This literature review highlights insights relating to the type of talent firms need to invest in, alongside AI specific infrastructure and business processes. It is worth noting that academic research on this topic is still emerging; as a result, this paper draws heavily from management consulting firms' publications, which are among the most prominent sources of literature available.

Given Canada's poor track record of digital transformation and technology adoption generally, the challenges firms face in adopting AI are no surprise. Like other GPTs—such as electrification, mass production, and information and communication technology—AI's economic potential lies in its diffusion throughout the economy, but this will not be realized until complementary investments are made, a process that can take many years. For Canadian firms to effectively adopt AI and reap its productivity benefits, they will need to invest in the right talent, develop complementary infrastructure, and design and adhere to relevant business processes. However, the complex nature of AI, as well as the variety of applications businesses can adopt, make it difficult for them to know precisely the type of talent, infrastructure, and processes they will need, and how these investments should be integrated.

A better understanding of the specificities of these components will not only help business leaders gain insight into what is needed to successfully adopt AI, but will also provide insights into the kinds of policy and training supports needed to maximize AI's productivity benefits across Canada's economy.

WHAT IS AI AND WHY DOES IT MATTER?

While there is no universally accepted definition of AI, it is possible to identify commonalities across the variety of available definitions. McKinsey, for example, defines AI as "the ability of a machine to perform cognitive functions we associate with human minds, such as perceiving, reasoning, learning, and problem solving" (Berube, 2018). Similarly, Deloitte (2018) defines AI as "systems and applications that perform tasks that mimic or augment human intelligence, ranging from simple gaming to sophisticated decision-making agents that adapt to their environment."

An important subset of AI is machine learning (ML), which refers to the ability of a program to detect patterns in data and continuously improve its pattern-recognition capabilities by interacting with more data (Berube, 2018). ML is the backbone for a range of related technologies and applications that can be used by businesses, such as natural language processing, robotics, virtual agents, and computer vision (Bughin et al., 2017).

The Potential of Prediction

The power of AI to enable profound changes in how businesses operate and produce value lies in its ability to predict: using data to generate information about the past, present, and future. Advances in computing power, along with increased access to and storage of big data, have enabled AI to predict "increasingly better, faster, and cheaper" than humans (Agrawal, Gans, and Goldfarb, 2018). AI's prediction function can been seen in a wide range of applications. For example, natural language processing (NLP) applications can predict what a user might be searching for by drawing on patterns in data on users' prior inputs and the inputs of others in similar circumstances. Comparatively, computer vision applications can predict the type of object they "see" based on previous sets of digital inputs.

The potential for accurate and timely prediction has substantial business value as it addresses uncertainty — a core business challenge across sectors and activities. AI also has the potential to decrease the cost of prediction insofar as it uses fewer human and other resources. As AI-enabled prediction becomes cheaper, its use across businesses could increase. However, the decreased cost of prediction will increase the value of complementary processes, such as human judgement and action.

GLOBAL AI ADOPTION TRENDS

Canadian firms are not alone in facing AI adoption challenges. There has been a recent increase of AI investments around the world, most of which have been dominated by digitally native companies focused on conducting their own research and development (R&D) and creating their own AI products and services. According to a study conducted by McKinsey, 60 percent of all external investments — consisting of corporate mergers and acquisitions, venture capital financing, private equity funding, and early-stage funding — in 2016 were directed to machine learning and deep learning (Bughin et al., 2017). That same year, global tech giants, such as Google and Baidu, spent an estimated $20 to $30 billion on AI with 90 percent of investments directed to R&D and deployment, and 10 percent to AI acquisitions (Bughin et al., 2017). The same study found that among 3,000 AI-aware C-level executives from 10 countries and 14 sectors, just 20 percent report that their organizations currently use "AI related technology at scale or in a core part of their businesses" (Bughin et al., 2017). However, outside of the tech sector, AI adoption tends to be experimental, with few businesses choosing to implement AI as a permanent business solution (Bughin et al., 2017). This suggests that sectors which have historically led in digital adoption are leading in AI adoption (Bughin et al., 2017).

Moreover, the gap between the laggards and

AI adoption leaders is set to grow, with early adopters already benefiting from the competitive advantages AI affords to their business (Bughin et al., 2017). Businesses who are not yet investing in AI risk becoming relatively less competitive and productive than the AI adoption leaders. This is a trend similar to the technology diffusion and associated productivity growth performance gaps between global frontier firms and laggard firms within OECD countries (Andrews, Criscuolo and Gal, 2015).

CANADIAN AI ADOPTION TRENDS

Canada's prominence in AI research should continue, with significant federal support through the Pan-Canadian Artificial Intelligence Strategy ($125 million CAD) as well as the $230 million SCALE. AI Innovation Supercluster investment (Prime Minister of Canada, 2018). Alongside federal-led efforts is a suite of provincial-level investments in research and education. In 2017, the Government of Ontario announced $50 million to create the Vector Institute and an additional $30 million to increase the number of AI graduates in an effort to stimulate foreign investments, attract companies, and stimulate job creation (Kirkwood, 2019). The Government of Quebec has also committed $60 million to support the AI-Powered Supply Chains Supercluster (SCALE.AI), alongside federal government funds. Additionally, the previous Alberta government had earmarked $100 million for artificial intelligence research and investment attraction.

Recent research points to growing private sector AI R&D and startup activity. One study found the number of active AI-related startups increased by 28 percent between 2017 and 2018, raising the total number of AI startups to about 650 across Vancouver, Edmonton, Waterloo, Toronto, Ottawa, Montreal, and Quebec City (Gagné, 2018). The same study found that, between 2013 and 2018, AI-related deals — including venture backed investments as well as corporate acquisitions and internal investments — increased by 49 percent (Gagné, 2018). Notably, during this time period, 62 percent of these investments were made by Canadian funders, versus 40 percent by international investors (Gagné, 2018).

Growth in AI startup creation and venture capital investment is contributing to growing demand for AI talent. Research conducted by Indeed.com found that Canadian AI and machine learning job opportunities grew by nearly 500 percent between June 2015 and June 2017. Of these jobs, 37 percent were located in Toronto and 61 percent were for machine learning engineers (Zubairi, 2017).

However, less progress has been made in terms of firm-level AI adoption. One survey found that just 16 percent of Canadian businesses surveyed reported using AI technologies between 2017 and 2018, a result that has not changed since the previous survey in 2014 (Stuart et al., 2018). Another survey conducted by Deloitte (2018) found that 67 percent of Canadian business leaders reported that they had spent less than $5 million each in the 2017-2018 fiscal year on AI, and results from other studies signal that these trends are not set to change in the near future. For example, McKinsey found that while 89 percent of Canadian business leaders expect AI to have considerable positive impacts within the next five years, only 34 percent have developed a long-term strategy focused on incorporating AI into their company (Bérubé et al., 2018). A study conducted by Deloitte had similar findings, with only 8 percent of Canadian companies reporting that they plan to increase their spending on AI by more than 20 percent by 2019, which is 40 percent less than the global average (Deloitte, 2018).

Previous research conducted by the Brookfield Institute for Innovation + Entrepreneurship on automation trends in Ontario's manufacturing and finance sectors found that while interest in adopting technologies to improve competitiveness and maintain output levels (particularly when faced with an aging workforce or new competitors) was strong, many firms delay adoption due to factors such as cost, risk aversion, and lack of skills

and expertise (Lamb, Munro and Vu, 2018).

In some respects, Canadian firms' limited progress in adopting AI is unsurprising. Canadian firms have lagged international peers in technology adoption generally (Conference Board, 2019). In 2004, Canadian business sector investment in ICT, as a share of GDP, was just 61.6 percent of comparable U.S. investments (Centre for the Study of Living Standards, 2005). In a more recent study, Canada's ICT investment made up 2.14 percent of GDP, while US investments accounted for 3.15 percent of GDP (Conference Board, 2018).

Although AI promises unique benefits, Canadian firms may view it simply as one among other possible technologies, which they have been historically slow to adopt. Moreover, it is possible that AI adoption among firms may be even slower than previous technologies owing to both real and perceived complexity and legal as well as consumer sensitivities. Adopting new technologies has been challenging for Canadian firms, and AI might pose even greater challenges (Mateos-Garcia, 2018).

APPROACHES TO ADOPTION

Firms that choose to adopt AI can take a variety of approaches. The two most common are the procurement of AI products from external providers and in-house development. Procurement refers to companies adopting of "off-the-shelf" or "custom-made" AI products from external providers who specialize in developing AI business solutions (Bérubé et al., 2018). This is similar to the way that firms buy existing software packages like Microsoft Office or customized customer relationship management (CRM) systems from technology providers. Alternatively, firms can develop in-house, firm-specific AI technologies and systems by hiring talent in order to produce new AI-based goods and services (Bérubé et al., 2018). According to a survey conducted by Deloitte, 53 percent of respondents prefer in-house development over outsourced development, while 43 percent prefer buying and integrating an outsourced product over integrating an off-the-shelf product (Bérubé et al., 2018).

Early AI Technology Adoption Examples

While overall adoption trends in Canada lag global peers, there are some documented examples of early adoption from which insights can be derived.

For example, firms in the financial sector are utilizing interactive assistants to help customers:

+ ATB Financial, an institution that provides financial services to Albertans and Alberta-based businesses, launched a virtual banking assistant that enables users to make transactions through Facebook Messenger (Ligaya, 2018).

+ The Royal Bank of Canada's AI-driven virtual assistant, NOMI, provides customers with insights on managing their finances (Deloitte, 2018).

+ Toronto-Dominion Bank announced an agreement with Kasisto to integrate its AI-powered interactive chat interface into the bank's mobile app (Ligaya, 2018).

Outside of the finance sector, Minestar Group, the largest Indigenous-owned oil and gas service provider in Western Canada, is beginning to utilize an AI-enabled bid advisor to help speed up its bidding process (Deloitte, 2018).

WHAT RETURNS ARE EXPECTED?

While there is currently a very small body of research examining firm and sector specific returns, it has been estimated that AI could deliver CAD $17 trillion of economic impact worldwide by 2030, boosting global GDP by approximately 1.2 percent each year (Bughin et al., 2018).

Companies must make initial investments associated with learning and integrating AI into their business practices before experiencing productivity benefits, however, which can take years, and productivity gains eventually plateau (Bughin et al., 2018; and Brynjolfsson, Rock, and Syverson, 2018).

REASONS FOR WEAK AI ADOPTION

Many of the barriers associated with AI adoption are similar to those that have slowed the adoption of previous technologies. There are some barriers to AI adoption that are likely to affect all organizations, while others may be shaped by sector and by firm-specific factors such as location, size, nature of operations, and supply chain characteristics. Recent research conducted by the Brookfield Institute for Innovation + Entrepreneurship found that while some barriers to adopting new technologies were similar across sectors—including access to skilled workers and cost considerations—some barriers were more sector-specific, such as concerns about regulatory hurdles and legacy systems in the finance and insurance sector (Lamb, Munro and Vu, 2018). The following section highlights key barriers identified in available literature.

FINANCIAL UNCERTAINTY + RISK

Uncertainty regarding the expected return on investment (ROI) is a primary concern preventing AI adoption, particularly among smaller firms where resources are limited (Bughin et al., 2017).

This aversion to risk can be explained using two phenomena: the "productivity paradox" (Brynjolfsson, Rock and Syverson, 2018) and the "innovator's dilemma" (Christensen, 1997).

The productivity paradox is a useful lense through which to view the impact of technology on productivity. This paradox refers to the J-Curve phenomenon whereby total factor productivity initially decreases as a firm invests in the labour and equipment needed to successfully adopt a new technology. This is due to the fact that investments in unmeasured, intangible capital will be larger than investments in measurable, physical capital assets, creating a paradox between the amount of investment being made and the productivity gains felt (Brynjolfsson, Rock and Syverson, 2018). This will remain the case until these hidden intangible assets begin to impact measured tangible production, measured in either labour productivity or output (Brynjolfsson, Rock and Syverson, 2018).

Similarly, the innovator's dilemma refers to the problem firms face when they need to direct attention and resources to innovation — such as adopting new technologies — but, in doing so, leave existing operations with less of the resources and attention they need in order continue normal, profitable functions. Faced with this dilemma, many firms simply choose not to innovate, thereby putting themselves at a long-term competitive disadvantage, or direct insufficient resources to innovation, thereby making success less likely. Complicating the problem is the fact that innovation is complex and future returns uncertain. Given the challenges associated with selecting a relevant AI application, calculating the benefits and risks of change, and determining the appropriate kinds and levels of resources needed for change, many firms simply decide not to roll the dice.

At its core, the barrier of financial uncertainty and risk—in the context of technology adoption— is also human capital issue, signaling the importance of managerial expertise or external support in areas such as risk calculation, diversified portfolio management, and digital transformation, to make informed AI investment decisions and long-term business strategies.

LIMITED TECHNOLOGICAL UNDERSTANDING

AI presents a number of complexities, associated with the technical requirements, options, limitations, and underlying architecture that differs depending on application. For this reason, uncertainty around whether and how AI should be implemented and used within a business is a common hurdle firms experience.

Currently, many Canadian businesses lack awareness of the kinds of AI-driven business applications that are on offer (Deloitte, 2018, p. 19). At the same time, many business leaders have little understanding as to what AI can do, or how it can be implemented, to improve their business (Deloitte, 2018, p. 19). Even among early adopters who are already experiencing benefits from AI, 68 percent reported little familiarity with the technological applications and suppliers they are working with (Deloitte, 2018).

Canadian firms are also unprepared to deal with the consequences of AI-driven systems. This includes unintended consequences that may result from "making wrong decisions based on AI recommendations," cyber security vulnerabilities, and unclear legal responsibility (Deloitte, 2018). In a survey conducted by Deloitte, 81 percent of early adopters expressed significant concerns regarding the risks associated with their firm's AI initiatives. Additionally, 64 percent of those concerned have revealed they are "not fully prepared to deal with" the potential consequences (Deloitte, 2018). The unease regarding potential consequences can be at least partially attributed to a growing number of public examples of bias in machine learning driven systems and growing public concern about questions of data governance (c.f. Dastin, 2018; Angwin et al., 2016). Overall, the lack of policy and institutionalized frameworks related to risks such as bias, privacy, and security create a high degree of uncertainty around what steps firms should take to mitigate them, and how they should respond if they occur.

ORGANIZATIONAL STRUCTURE + CULTURE

In order for businesses to maximize the benefits of AI, they will need to develop new business strategies, organizational hierarchies, processes, and policies.

Integrating AI into companies' roles and functions was the most cited challenge by business leaders in Deloitte's survey, at 40 percent. Taking this into consideration, it should be no surprise that only 34 percent of business leaders reported having transformed their firm's long-term strategy to properly position themselves to reap the benefits of AI (Bérubé et al., 2018). However, it should not be assumed that AI will benefit every firm—there are cases where adoption does not make sense, which may explain why some of these businesses lack AI strategies.

Where businesses would benefit from AI adoption, they often face difficulties that are deeply rooted in their structure and culture. Established organizational behaviours, attitudes, and structures can make it difficult to adopt new technologies, which require new business processes, managerial practices, and talent (Conference Board, 2015). In fact, research has found that employees have limited tolerance for organizational transformation, and firms may encounter a lack of motivation or even resistance to innovative changes (Conference Board, 2015).

LACK OF INFRASTRUCTURE

While the literature discussing infrastructure barriers to AI adoption is limited, this is reported to be an important factor. Bérubé and colleagues (2018) cite infrastructure as one of the foundational elements to AI adoption. Bughin and colleagues (2018) highlight digital infrastructure as a core indicator of AI adoption readiness. They also explain that the effective adoption of AI may be dependent on the existence of technical infrastructure (Bughin et al., 2018).

Although the literature finds that firms have

concerns about infrastructure as a component of AI adoption, clear definitions and delineations of the term are not provided. However, other literature on innovation more generally provides some guidance. In their work on the growing importance of the intangible economy, Haskel and Westlake (2018) define infrastructure as both physical assets—such as work spaces and equipment—and intangible factors—such as rules, norms, and institutions. Applied to AI, then, we might understand infrastructure as both the physical assets, such as technology hardware, and intangible capital, such as software, data, norms, rules, and institutions, that are needed to develop, operate, and use AI applications.

Deloitte (2018) found that integrating AI into existing infrastructure is the second most common barrier that businesses report. In fact, many companies lack the digital infrastructure, both hardware and software, needed to support AI and its various components. In a global survey conducted by McKinsey, just 15 percent of 1,646 companies surveyed reported having the right technological infrastructure and architecture in place to support AI (McKinsey&Company, 2018). Within Canada, there is evidence that these infrastructural barriers differ by industry and size. Many large banks, for example, have legacy systems that are incompatible with new AI applications and cumbersome to replace and update—an issue that many smaller, newer companies would not face (Lamb, C., Munro, D. and Vu, V., 2018; Bigham et al., n.d.).

Access to data is a necessary precursor to AI development and use. Therefore, even when firms have the required hardware and software, a lack of data, or inability to rationalize and aggregate it, is a key barrier to AI adoption. Deloitte's (2018) survey of 147 business leaders found that issues related to data are the third most cited challenge to AI adoption. This involves obtaining or accessing large sets of high quality data needed to train and utilize AI (Bigham et al., n.d.; Bughin et al., 2018). Additionally, if a firm chooses to use supervised learning as a method to train its AI system, the underlying training data must be labelled and categorized by humans for it to be interpretable by the machine (Bughin et al., 2018).

Alongside these requirements are a variety of rules, norms, and institutions that can encourage and protect firm-level AI adoption efforts. Intellectual property laws, for example, can encourage businesses to invest in intangibles by reducing negative spillover effects through copyrights, patents, and trademarks. However, when overly strong, broad, or vague, intellectual property laws can discourage innovation by hindering competition or making it difficult for companies to exploit beneficial synergies between intangibles. If designed right, norms and rules can help investors navigate the institutional complexities of, and benefit from, intangible assets (Haskel and Westlake, 2018).

COMMONALITIES WITH HISTORIC GPT ADOPTION TRENDS AND BARRIERS

Past experience with adoption—or failed adoption—of other GPTs can shed some light on AI adoption barriers and trends. GPTs are "pervasive, improve over time, and lead to complementary innovation" (Bresnahan and Trajtenberg, 1995). Using this definition, it is easy to see how AI, and ML in particular, can be regarded as a GPT, by virtue of its ubiquity within a wide range of sectors, ability to scale, and sizeable spillover effects (Deloitte, 2018).

One commonality across GPTs is the extensive investment required in both measured physical capital and unmeasured intangible assets in order to integrate new technology into existing businesses. The amount of investment required often leads firms to experience a sense of financial vulnerability, as returns are not guaranteed. As with AI, the productivity paradox is a phenomenon that can be seen across a number of previous GPTs. For example, the adoption of electricity required investment into electric grids, complementary technologies such as light bulbs, cables, and switches, the development of standards related

to voltage and the shape of plugs, and alteration of business products compatible with this new form of power (Campanella, 2018). Electricity took two decades to surpass steam, and a total of four decades to become the primary source of power over other available alternatives (The Economist, 2000). Only in the 1920s, 40 years after electric power had been introduced, did it contribute to productivity acceleration (The Economist, 2000).

Taking a closer look at a more recent GPT, Information and Communication Technologies (ICT), a number of parallels can be drawn in relation to barriers faced by AI adopters. As with AI, uncertainty and risk are a prominent challenge noted in the ICT adoption literature. In the 2007-2008 Survey of Innovation and Business Strategy (SIBS), 37 percent of respondents cited "risk and uncertainty" as a barrier to ICT adoption (Industry Canada, 2013). Similarly, a series of workshops with Canadian businesses, hosted by the Conference Board of Canada (2015), also uncovered concerns related to uncertainty and unpredictability related to costs and ROI in relation to ICT adoption. Related to these responses, the lack of internal financing and understanding of costs associated with ICT adoption was another major barrier cited in the literature (Industry Canada, 2013). Moreover, there was consensus within the literature regarding the challenge of acquiring and arranging expertise across organizations—a major hurdle for ICT adoption (Industry Canada, 2013; The Conference Board, 2015). As of 2018, Canadian business sector investment in ICT accounted for 2.14 percent of GDP, compared to 3.15 percent of GDP in the U.S. (Conference Board, 2018), signalling the difficulties of overcoming these barriers.

NECESSARY COMPONENTS NEEDED FOR ADOPTION

A survey of available literature shows that the right mix of talent, supporting infrastructure, and business processes are key enablers of successful AI adoption. While talent is a necessary component of its own, it is also a precondition for infrastructure and business processes.

TALENT

Gaps in specialist, managerial, and translation talent, as well as in re-training supports to empower existing employees to effectively use and work alongside AI technology, are contributing to deficiencies in understanding and expertise that are inhibiting successful AI adoption. Developing transformative AI applications for businesses will require teams that comprise a diversity of skill sets.

This includes individuals with proven technical skills in areas such as machine learning, data analysis, and programming to develop and train AI systems (Wilson, Daugherty and Morini-Bianzino, 2017). Alongside these technical skill sets, companies will require effective change management and leadership capacity to redesign internal processes, identify changing team needs, redevelop career pathways, and ensure organizational buy-in.

Firms will also need to invest in employees with the knowledge required to develop, implement, and navigate rules, norms, and institutions in order to address IP, privacy, policy, legal and ethical considerations associated with AI adoption and development. The amount of data required to effectively use AI will also require workers with experience dealing with the organization, storage, and cleaning of large data sets.

Additionally, firms will require individuals who can bridge the gap between business leaders and technologists—often referred to as translators or explainers (Wilson, Daugherty and Morini-Bianzino, 2017). Workers within this category will help to provide clarity on the potential and limitations of different AI applications and make recommendations regarding types of solutions and how to use them. Furthermore, businesses will also need to invest in individuals who will ensure a firm's AI solutions are operating as intended, flagging any unintended consequences that need to be addressed (Wilson, Daugherty and Morini-

Bianzino, 2017).

Firms have a variety of options on how they can access and deploy this talent. On the one hand, businesses can hire permanent full-time or part time as well as contracted in-house talent. On the other hand, firms can source talent from external organizations, such as support organizations, AI-solutions providers, and consulting agencies, to fill gaps in their workforce and support in-house staff.

Case-Specific Talent Requirements

The type of talent, and number of employees required will depend on whether a firm chooses to develop AI solutions in house or procure off-the-shelf solutions.

Developing solutions in-house will require: technology specialists whose skills and experience enable them to develop, adopt, and/or maintain AI technology; generalist IT skills and knowledge among all employees to effectively use AI; managerial expertise to identify and continuously evaluate talent and training needs; and translation skills to identify business cases, relevant applications, and associated risks (Deloitte, 2018).

Even when companies procure off-the-shelf AI solutions, they will need to determine what kind of internal talent will be needed to evaluate and monitor the performance of this technology (Bérubé et al., 2018, p. 11). This will likely include a combination of individuals with translation skills, management skills, and generalist knowledge, but talent needs may vary depending on the firm's sector as well as the nature and use of the AI application.

Regardless of the method of adoption, translation skills will play a large role. Translators include individuals who are able to bridge the gap between business teams and technical staff. Translators will be responsible for identifying technical opportunities, articulating challenges, and conveying solutions (Bérubé et al., 2018). This also includes AI ethicists, individuals who are technologically literate with backgrounds in social science, anthropology, psychology, or related disciplines (Murawski, 2019). These individuals are able to think critically about the human facing aspects and impacts of AI systems. While it is still early, there is growing recognition of the importance of workers trained in humanities or social science to navigating AI adoption.

Diversity

There is also growing recognition of the importance of a diversity of people and perspectives in supporting AI adoption. Early adoption and use of AI-enabled systems have revealed a range of biases along gender, race, and socio-economic characteristics which, arguably, could be better identified and addressed by teams with diverse experiences and backgrounds. There is some indication, however, that relevant talent pools may not reflect the diversity of Canada's labour market. Recent Brookfield Institute research on tech workers in Canada found that men are four times more likely than women to work in a tech job (Vu, Lamb and Zafar, 2019). While this statistic looks at the tech sector in general, a portion of which is made up by AI jobs, it does indicate that companies looking to identify the talent needed to successfully adopt AI may not be pulling on as diverse of a talent pool as they could be.

What Do We Know About the AI Talent Pool?

Even where we know that certain skills and talent are needed for effective and responsible AI adoption, there is great uncertainty about the extent to which the talent exists in the labour market. There are weak signals in existing data sources, but given how new AI is to the economy, standard skills and occupations databases and measures are not yet up to speed.

While available labour market data, for example from the National Occupation Classifications (NOCs), O*Net, or Burning Glass Technologies, can be used to map talent according to geography, industry, demographic characteristics, and skills distinguishing AI-related jobs from other tech occupations is challenging, and not all AI-related jobs fall under the tech umbrella.

Additionally, there is sparse literature on what job types and skills apply, or on whether the supply of relevant talent is sufficient. Recent research conducted by Element AI (Gagne, 2019) found 36,524 self-reported AI specialists globally by searching for "data scientists," "data analyst", "research scientist", "machine learning engineer", and "machine learning researcher" on Linkedin. Just 1,487 of these profiles indicated they were located in Canada (Gagne, 2019). While this research provides a snapshot of the number of people with self-reported technical, doctoral-level AI expertise, it does not provide a full picture of AI relevant talent, and the range of roles and particular skills remains largely unknown.

While data on AI-specific talent is not readily available, analysis of Canada's broader tech talent pool can be used as a partial proxy for AI talent. The Brookfield Institute for Innovation + Entrepreneurship's recent report, Who are Canada's Tech Workers?, measured the tech workforce in Canada, including demographic and geographic characteristics. Notably, it found that while Canada's tech workforce is diverse, there are disparities in pay and participation across many demographic lines.

INFRASTRUCTURE

Deploying AI effectively requires strong digital infrastructure that can support large data sets and continuous iteration. AI relies on a range of digital hardware and software components, regardless of whether these are cloud or location based. However, even when this technological backbone is in place, firms will not be able to generate value from AI without access to the skilled labor and experience needed to operate and maintain this infrastructure (Bughin et al., 2018).

The success of AI-driven business solutions lies in a firm's ability to collect, organize and control large stores of data, regardless of the business case (Medhora, 2019). The amount of data a business is able to acquire is a key factor as it enables a firm's algorithms and predictions to become more accurate than its competitors (Deloitte, 2018). However, collecting data on its own does not enable businesses to use it. In order to add value to companies, data must be labelled and characterized—a process which generally requires individuals to manually label information. This draws on firm resources—labour, time, and finance (Bérubé et al., 2015).

Having a clear data strategy is a critical component to prevent data silos and ensure the value of data is accessible throughout the firm (Ward, 2018). In addition to data warehouses, integrating data

collected across a firm may require the creation of a data lake—a centralized repository where firms can store structured and unstructured data at any scale (Ward, 2018; Amazon Web Services Inc., 2019). Companies that have undergone mergers or acquisitions may have a variety of data sets that are structured differently, raising questions around ownership and standardization (Ward, 2018). Firms may want to invest in developing a data governance strategy and clearly articulate IP frameworks to ensure privacy and security of information as well as the sharing of beneficial data (Ward, 2018; Haskel and Westlake, 2018).

BUSINESS PROCESSES

While acquiring the right kind of talent and infrastructure is critical to the successful adoption of AI, firms will need to invest in appropriate business processes and supports to properly integrate and derive maximum value from these components.

In order to incorporate the necessary talent, firms will need to reconsider or develop new roles and career paths (Bérubé et al., 2018). This not only includes building in organizational agility to quickly deploy systems, position assets, and organize people to take advantage of new opportunities or manage risks, but also requires developing, promoting, and accepting new ways of working and making decisions to improve a firm's ability to overcome bureaucratic roadblocks that hinder transformative change (Stuart et al., 2018).

Establishing an innovative, resilient, and collaborative culture can help companies withstand disruption associated with organizational and technological transformation (Bughin et al., 2017; Stuart et al., 2018). Even after successfully adopting a new technology, firms can benefit from encouraging innovative behaviour and practices to continue to identify and generate value from potential spillover effects (Stuart et al., 2018).

Organizational buy-in, at all levels, is another core success factor for businesses looking to adopt AI. Business leaders will need to ensure their employees are prepared for, and understand, the importance of adopting AI. This requires constant communication and clear articulation of the purpose of each step (Bérubé et al., 2018).

CONCLUSION

AI offers profound benefits to companies that are able to leverage data to inform and reshape their business processes, services, and products. While Canada has shown great promise in the form of sizable public sector investments in AI R&D and start-up activity, limited progress has been made in terms of firm-level AI adoption. A review of available literature and data indicates that Canadian firms are slow to adopt AI due to gaps in technical, managerial, and translation talent required to support the effective development, implementation, and use of fundamental AI infrastructure, develop effective business strategies, calculate risk, manage business processes, and identify and address unintended consequences.

KEY QUESTIONS THAT REMAIN

Based on the literature to date, there are significant gaps regarding both the barriers Canadian business leaders are currently facing, and the specific kinds of talent, infrastructure, and processes businesses needed to successfully adopt AI.

Further research is needed to answer the following questions, in particular:

+ For firms that have successfully adopted AI, what were the key success factors? What returns are they witnessing?
+ What talent do firms need, throughout their organizational structure, to successfully navigate AI adoption challenges? What organizational structures and business processes are required to integrate this talent and successfully adopt AI? How do these needs differ by company size, industry, and business type?
+ What skills do organizations struggle to find?
+ Are organizations aware of the kinds of talent they need to adopt AI systems effectively?
+ To what extent does Canada's talent supply match the talent needs of companies seeking to adopt AI? How diverse is this talent pool?

Building on this literature review, the Brookfield Institute proposes to advance a robust research project to fill one of these knowledge gaps: building a detailed and actionable understanding of the talent and related investments needed to empower Canadian firms to evaluate and seize AI opportunities. This research will enable the creation of a first-of-its-kind typology of AI job and skill types including, but not limited to, technical, translational, and managerial expertise. It will also generate more detailed information on the common skills and organizational strategies Canadian firms need to successfully adopt AI systems. This proposed research will aim to fill key knowledge gaps, help shape company-level strategies and AI adoption policies, and inform the design of a potential pilot project aimed at developing a new approach(es) to supporting talent development for AI adoption.

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