Innovation, Science and Economic Development Canada
Innovation, Sciences et Développement économique Canada

INSIGHTS

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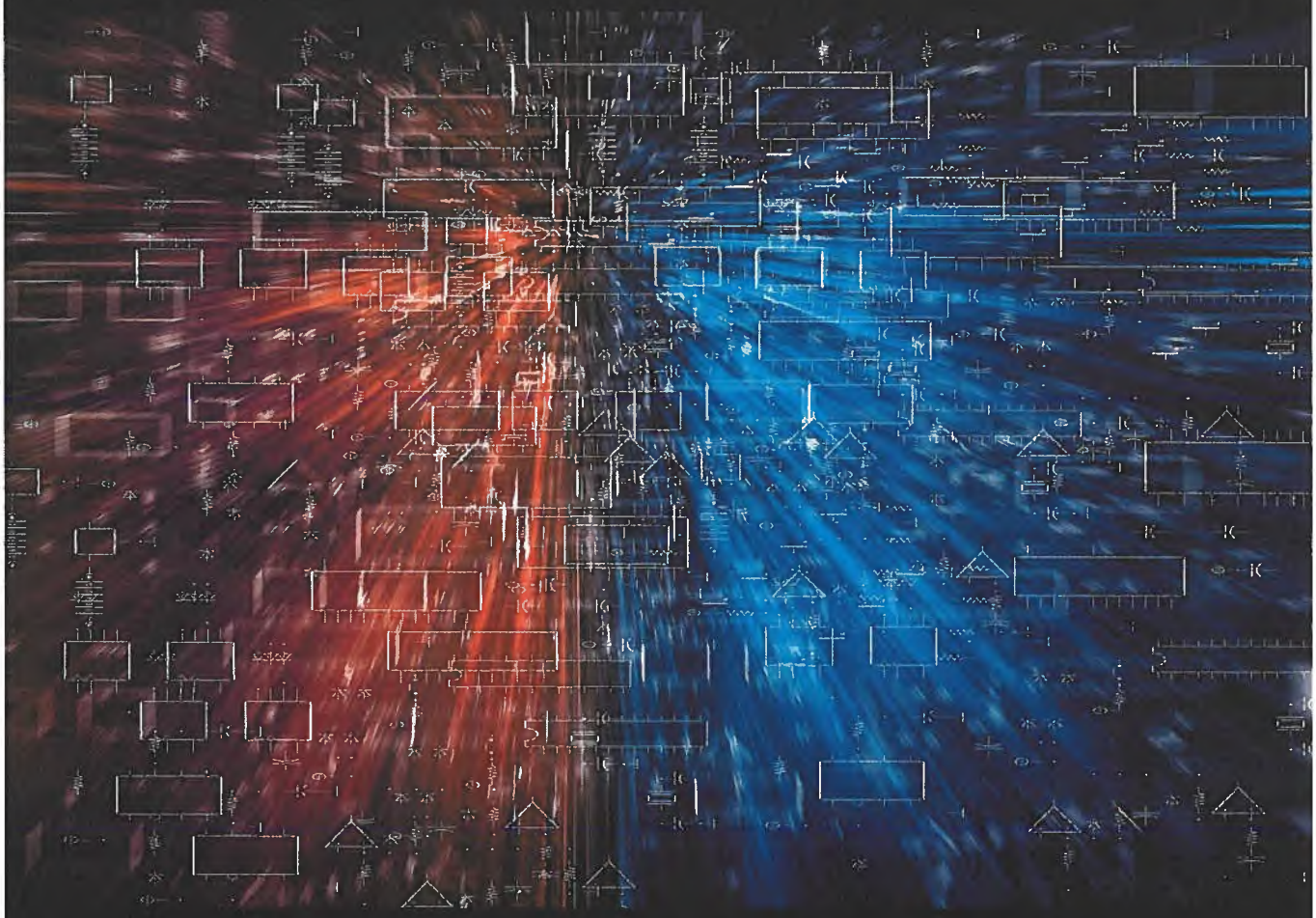


Competitiveness in an Age of Disruption, AI,

Productivity Advantage of Multinationals in Canada

Canada

FEATURE ARTICLES:

Artificial Intelligence: Current Government of Canada Initiatives

HIGHLIGHTS

- Artificial intelligence (AI) technologies and systems are already being widely used in Canada, and their effects will increasingly be felt across our economy and society going forward.
- Canada is a leader in AI research, meaning it is well-placed to be at the forefront of policy discussions on the future of AI, but there is considerable uncertainty regarding the future benefits and potential risks of AI.
- Current initiatives aimed at identifying best practices to help ensure that Canadians benefit from AI include: the Pan-Canadian AI Strategy, the Innovation Superclusters Initiative, the G7 Multistakeholder Conference on AI, and the International Panel on Artificial Intelligence.
- The Government of Canada is harnessing the opportunities provided by AI to improve the level of service it provides its citizens, while also addressing ethical concerns.

BACKGROUND

The Organisation for Economic Co-operation and Development (OECD) defines artificial intelligence (AI) as "the ability of machines and systems to acquire and apply knowledge and carry out intelligent behaviour."[1] First conceived in the 1940s, AI has advanced rapidly in the last 10 to 15 years due to the combination of vast quantities of data becoming available, the development of new mathematical techniques, and the cost of computing power falling considerably. This rapid advance has deep roots in Canada.

Certain forms of AI have already been used in industrial processes for several decades. More recently, however, some relatively new techniques have led to rapid progress in the development of AI technologies with the potential to be

[1] Organisation for Economic Co-operation and Development, "Transformative Technologies and Jobs of the Future - Background report for the Canadian G7 Innovation Ministers' Meeting (March, 2018), 13.

transformative across sectors.[2] One example is Precision Medicine in healthcare, which is leveraging the sweeping waves of digitalization and disruptive technologies to help interpret diagnostic findings, resulting in a more personalized approach to healthcare that is proactive as opposed to reactive.

New AI technologies are expected to lead to large advances in economic productivity. However, the timing and magnitude of these gains is up for debate. Rapid increases in productivity have been witnessed before, and it is unclear whether the impact of an AI-facilitated increase could be similar to the productivity jumps experienced in the 1890s, 1900s, 1950s, 1990s, and early 2000s.[3] Further, it may be years or even decades before this increase is fully reflected in Canada's GDP.[4] However large the impacts on productivity, Canada is well-placed to take advantage of the economic benefits afforded by AI, as Canadian researchers and institutions are at the forefront of research in key areas of this field.

CANADIAN LEADERSHIP IN MACHINE LEARNING

The dramatic improvements in AI over the past 10 to 15 years have been driven primarily by progress in machine learning, a subfield of computer science and AI that explores the study and construction of algorithms that can learn from, and make predictions based on, data. Unlike traditional algorithms that need to be explicitly programmed in order to achieve a particular outcome, machine learning algorithms are designed to "learn" from examples. As a result, machine learning techniques, in particular deep learning and reinforcement learning, have contributed to the achievement of breakthroughs in many traditionally challenging areas of AI.

Canadian AI researchers Geoffrey Hinton and Yoshua Bengio are pioneers in the field of deep learning. They are widely credited with sparking a renaissance in deep learning research, along with French national Yann LeCun, who joined Hinton's Toronto lab early in his career.[5] According to the OECD, deep learning technologies are now at the stage where they are ready to be applied in most industrial activities, which has the potential to generate rapid changes in the industrial sector.[6]

From right: Yoshua Bengio, Geoffrey Hinton, and Foteini Agrafioti speaking at the G7 Conference during a lunchtime panel moderated by Minister Navdeep Bains.

[2] Organisation for Economic Co-operation and Development, "Artificial Intelligence and the Technologies of the Next Production Revolution: Selected Policy Issues" in *STI Outlook 2018* (August, 2018), 3.
[3] Robert D. Atkinson, "Emerging Technologies and Preparing for the Future Labor Market," *Information Technology & Innovation Foundation* (March, 2018), 1.
[4] Ibid.
[5] Mark Bergen and Kurt Wagner, "Welcome to the AI Conspiracy: The 'Canadian Mafia' Behind Tech's Latest Craze," *redcode.net*, July 15, 2015, https://www.recode.net/2015/7/15/11614684/ai-conspiracy-the-scientists-behind-deep-learning.
[6] Ibid.

Richard Sutton

Edmonton-based Professor Richard Sutton is considered to be one of the founding fathers of modern reinforcement learning, having made several significant contributions to the field dating back several decades.[7] Reinforcement learning is also starting to be applied on a much broader scale on account of recent technological advances. Examples of practical applications of reinforcement learning include a video game learning how to challenge a human player, a mobile robot learning to move around a room while avoiding obstacles, and an adaptive controller learning how to manage and optimize resources in a production facility. Professor Sutton and some of his colleagues were instrumental in the decision by DeepMind, Google's centre for AI research, to open its only lab outside of London (United Kingdom) in Edmonton in 2017.[8]

Canada is now recognized for its strong talent base in the field of AI thanks in part to the work of these early pioneers, as well as crucial early investments on the part of the Canadian Institute for Advanced Research (CIFAR) in the 1980s and 90s. According to Element AI, a Montreal-based AI company and business incubator, Canada ranks third in the world in terms of its absolute number of AI experts, with over 1,154 PhD-educated researchers, which trails only the United States and the United Kingdom. Furthermore, students in the STEM (Science, Technology, Engineering, and Mathematics) fields currently make up one-quarter of university students and over half of all PhD graduates in Canada.

POTENTIAL CHALLENGES

With all of the potential benefits of AI also come concerns. OECD estimates suggest that about 14% of all workers are at high risk of having most of the tasks they currently perform automated over the next 15 years, while fully half of all workers will need to adapt to significant changes to their work environments.[9] Although AI will undoubtedly lead to new jobs being created, it is likely that these jobs will be substantially different from those that they are replacing. In fact, recent trends in job polarisation, where middle-skilled jobs are being replaced by high- and low-skilled jobs, have raised concerns and elicited calls for greater efforts to prepare the workforce for the jobs of the future.[10]

Other questions relate to issues of privacy, transparency and accountability, ethics, and cybersecurity. One particular area of concern is how AI will affect different social groups, including how the changing job market will affect men and women differently. Currently, women occupy more of the jobs at risk than men (figure 1). As such, the Government needs to determine whether this situation will prevail in the future and, if so, what can be done to mitigate the effects of job losses on women.

It is in these questions, among others, that the Government of Canada is working to address. Being the centre of innovation policy in the federal government, Innovation, Science and Economic Development Canada (ISED) is the department that will lead the way.

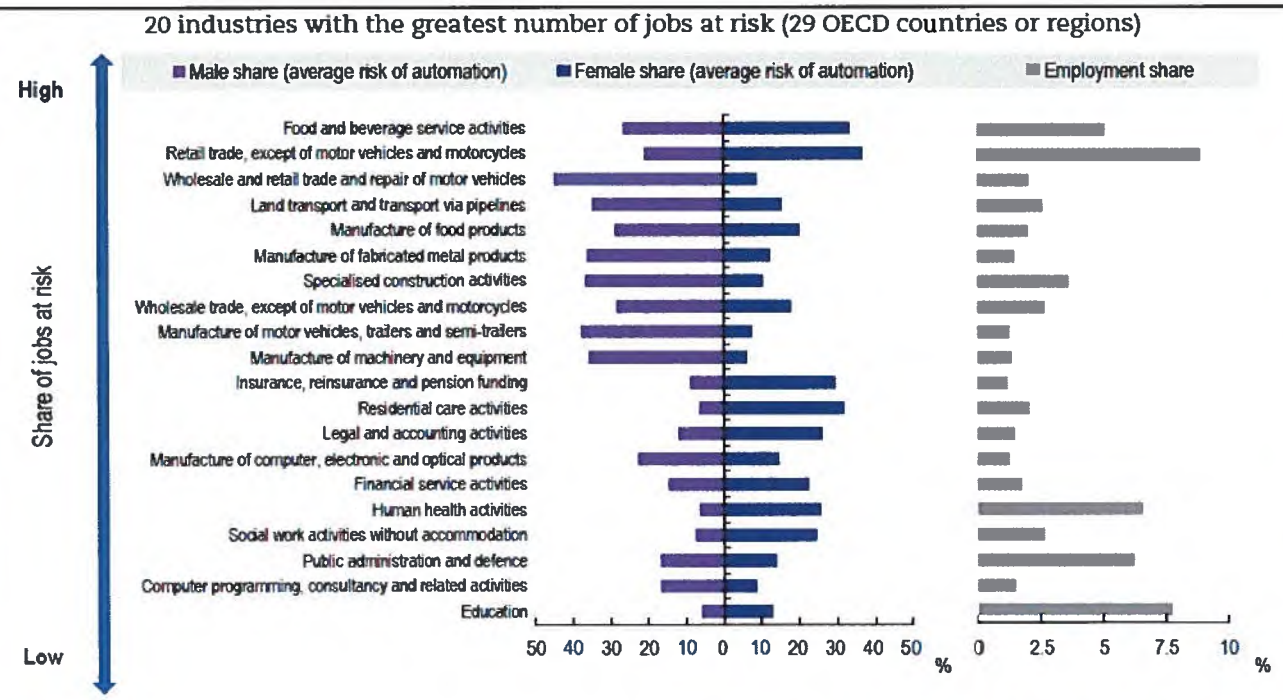
[7] "Interview with Dr. Richard Sutton," *medium.com*, January 11, 2017, https://medium.com/syncedreview/interview-with-dr-richard-sutton-we-might-have-strong-ai-algorithms-by-2030-a1052332d878

[8] Katherine Kerr, "Why Google DeepMind makes its Second Home in Edmonton," *Edmonton.com*, March 28, 2018, https://www.edmonton.com/home-2/deepmind.

[9] Organisation for Economic Co-operation and Development, "Transformative Technologies", 7.

[10] Ibid.

Figure 1: The Average Risk of Automation by Industry



Notes: The chart shows the 20 industries with the greatest number of jobs at risk (measured as the average risk of automation weighted by the employment share of the industry), in descending order of overall risk of automation (left panel). The width of each bar in the left panel represents the average share of jobs at risk in each industry. The placement of each bar relative to the centre line depicts how that risk is shared between men (light blue) and women (grey). Values in the right panel represent the share of total employment held by each industry. Risk of automation values are based on likelihoods calculated in Arntz, Gregory and Zierahn (2016). Countries covered in this analysis include the 29 OECD countries that participated in the first and second rounds of the Survey of Adult Skills.

Source: OECD (2017e), "Going Digital: The future of work for women", https://www.oecd.org/going-digital/Going-Digital-the-Future-of-Work-for-Women.pdf.

GOVERNMENT OF CANADA INITIATIVES

Given the potential benefits and challenges of AI, the Government is moving forward with the following initiatives:

Pan-Canadian AI Strategy

Budget 2017 provided $125 million to launch a Pan-Canadian Artificial Intelligence Strategy. The strategy, which is led by CIFAR, promotes collaboration between Canada's main centres of expertise in AI: Toronto-Waterloo, Montreal, and Edmonton. It ultimately aims to position these centres as world-leading destinations for companies investing in AI by supporting the research, training and industry engagement activities of a key AI institute based in each of them: Amii in Edmonton, the Vector Institute in Toronto, and Mila in Montreal.

The Budget also established the Canada-CIFAR AI Chair Program to assist in the recruitment and retention of top academic researchers in Canada, and contribute to building a strong foundation of scientific excellence that will help attract additional AI talent to these AI institutes.

Innovation Superclusters Initiative

The Government's Innovation Superclusters Initiative contributes $950 million in public funds to partnerships intended to spur innovation in industry clusters with high growth potential. The five superclusters selected represent more than 450 businesses, 60 post-secondary institutions, and 180 other participants across five regions, namely, British Columbia, the Prairie provinces, Ontario, the Quebec-Windsor corridor, and Atlantic Canada. Use cases for artificial intelligence are widespread, and all of the superclusters selected are planning to support projects that will promote the development or application of AI in their respective industries. In particular, the Montreal-based AI-Powered Supply Chains Supercluster (SCALE.AI) intends to undertake activities to develop next-generation AI-powered supply chain platforms and integrate cutting-edge technologies, such as robotics, into supply chain management.

G7 Multistakeholder Conference on Artificial Intelligence

The G7 Multistakeholder Conference on AI, which took place in Montreal on December 6, 2018, brought together more than 200 AI experts from G7 countries, representing the public and private sectors, civil society, academia, and research institutions, for a deeper exploration of practical perspectives to inform collective action. More specifically, the one-day conference facilitated multistakeholder discussions on the issues of inclusion in AI development and deployment, reducing barriers to innovation, promoting greater societal trust, and ensuring that workers obtain the skills required for the modern economy.

International Panel on Artificial Intelligence

On June 7, 2018, Prime Minister Trudeau and French President Emmanuel Macron announced their shared vision for an international body on artificial intelligence. Subsequently, at the G7 Multistakeholder Conference on AI, Prime Minister Trudeau and French Minister for Digital Affairs, Mounir Mahjoubi, announced the creation of the International Panel on Artificial Intelligence, whose mission statement is to "support and guide the responsible adoption of AI that is human-centric and grounded in human rights, inclusion, diversity, innovation and economic growth", and whose mandate includes producing reports and assessments at the request of its members.

Government of Canada Advisory Council on Artificial Intelligence

On May 14, 2019, the Honourable Navdeep Bains, Minister of Innovation, Science and Industry, announced the launch of the Advisory Council on Artificial Intelligence. The council will advise the Government of Canada on how best to: build on Canada's AI strengths; identify opportunities to create economic growth that benefits all Canadians; and, ensure that AI advancements reflect Canadian values. Specifically, the council will establish a working group on commercializing value from Canadian-owned AI and data analytics, building on the work started by the Digital Industries Economic Strategy Table. It will also provide advice on how to advance the goals laid out in the Canada-France Statement on Artificial Intelligence and support Canada's participation in various international fora, such as the G7, the G20, the OECD and the World Economic Forum.

Other Initiatives

Other government initiatives include: the Strategic Innovation Fund, which attracts and supports high-quality business investments, including investments in AI, within a variety of industries; the Global Skills Strategy, which makes it easier for

Canadian companies to attract and bring in global talent; and, the Future Skills Centre, which will fund projects aimed at identifying emerging skills and innovative ways to develop those skills, and then share their results and any identified best practices with all sectors and Canadians.

AI IN THE FEDERAL GOVERNMENT

The federal government is a direct user of AI technologies in order to provide Canadians with a more personalized and efficient service experience that is responsive to their needs. Examples include:

- ISED has issued a public challenge via the Innovative Solutions Canada program to develop a novel digital tracing system, enabled by blockchain and AI, to trace inputs and outputs within the steel supply chain in real time. ISED would directly benefit from such a technology as it would facilitate and enhance evidence-based policy making.

- Employment and Social Development Canada is using AI to make more proactive decisions, automate a number of manual processes, leverage unstructured data assets, and prepare the department for future technologies.

- Immigration, Refugees and Citizenship Canada is using advanced analytics and AI to streamline the processing of temporary resident visas, as well as work and study permit applications from China and India.

- Natural Resources Canada is developing AI-based algorithms and decision agents, in collaboration with the private sector, the National Research Council, and academia, to help maximize productivity and system efficiencies for industrial processes in pulp and paper operations.

In order to provide federal institutions with guidance on how to use automated systems that assist with or render administrative decisions, the Treasury Board of Canada Secretariat has developed the Directive on the Use of Machine Learning for Decision-Making. It is intended to help institutions harness the benefits of automated decision-making systems, such as more efficient, accurate, and consistent decisions, while mitigating the associated risks, including their negative impacts on vulnerable populations. To facilitate this, the Government has developed the Algorithmic Impact Assessment (AIA), a tool to assist federal institutions in assessing the level of risk associated with an automated decision system by providing an impact level tied to specific requirements of the Directive. The AIA is one of the first tools of its kind, and was developed in consultation with expert stakeholders at the Government of New Zealand, New York University, Harvard, and the Vienna University of Economics and Business.

IMPLICATIONS FOR ISED

Since the 1970s, early investments in Canadian researchers have allowed an AI industry to develop and bloom. In particular, advances by Canadian pioneers in the area of machine learning have positioned this country as a global leader in AI research, development, and application. As a result, Canada ranked fifth on The Economist's 2018 Automation Readiness Index, which compares countries according to their preparedness for AI- and robotics-based automation by assessing their innovation environments, and education and labour-market policies. Canada's ranking is largely attributed to federal initiatives that support technology innovation and address the workforce effects of automation, as well as provincial efforts to adapt educational systems to the demands of emerging technologies.

This article highlighted important Government initiatives that will help prepare Canadians for the coming changes that new AI technologies will bring to our economy and society. As the centre for innovation policy, ISED is leading major federal initiatives that will shape the future of AI in Canada.

Author:	Daniel Ribi, Student, AI Hub *Innovation, Science and Economic Development*
For further information about this document contact:	Christopher Zakhem *Innovation, Science and Economic Development* christopher.zakhem@canada.ca +1 (343) 548-1815

Competitiveness in an Age of Disruption: Drivers Behind Productivity and Innovation in the New Digital Economy

HIGHLIGHTS

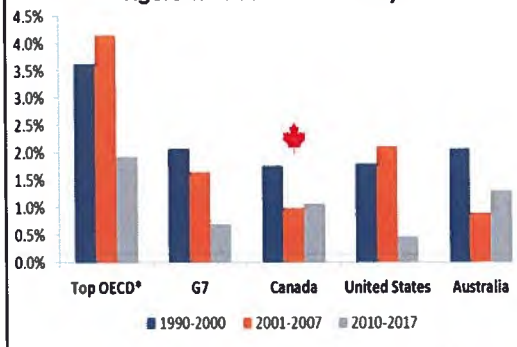
- In the new digital economy, Canadian firms face a dynamic environment, where traditional firm-level perspectives may not apply.
- Data is becoming one of the most important inputs in the production process, resulting in the emergence of a platform economy and increasing sector interconnectivity, with implications for how firms compete and the development of competition policies.
- The new realities of the digital economy present both opportunities and challenges. The Government of Canada needs to ensure that Canadian firms can stay competitive in this new environment.

BACKGROUND

Productivity is the engine of sustainable economic growth, fuelling both the living standards of individuals and the competitiveness of firms in the economy. This is particularly true in Canada, where an ageing population means that any sustainable economic growth going forward needs to be based on productivity growth. However, Canada's productivity performance has lagged behind those of its Organisation for Economic Co-operation and Development (OECD) peers over the past two decades.

Given this subpar performance, it is important to understand drivers behind firm-level productivity in order to improve it. This involves understanding the rapidly-changing environment that firms are facing in the digital economy. In particular, Canadian firms are required to make various decisions while taking new information and factors about

Figure 1: Labour Productivity Growth



* Average labour productivity growth of the top half of OECD countries.
Source: OECD productivity indicators

the digital economy into account. This article attempts to lay out the drivers underpinning this new dynamic environment, and determine where Canadian firms stand. In doing so, we hope to shed light on the opportunities and challenges faced by Canadian firms in the digital economy, which would help Innovation, Science and Economic Development Canada (ISED) develop effective policies to help Canadian firms stay competitive.

INTERNAL DRIVERS

Technology Adoption

A country's productivity reflects, in part, capital deepening, or the growth in capital input per worker. This can occur through general capital investment, as well as through the adoption of new technologies, which can boost the competitiveness of Canadian firms through innovation and productivity growth. However, Canadian firms are lagging other countries in terms of technology adoption. For example, real information and communications technology (ICT) investment in Canada grew only 0.55% from 2006 to 2014. In 2014, Canadian private sector investment in ICT per worker was 56% of the US value, while investment in computer software and databases on a per job basis was only 49% of that in the United States (US). Further, evidence shows that emerging technologies (e.g., nanotechnology, artificial intelligence (AI), blockchain) are more likely to be adopted by large firms (29.1%) as opposed to small (17.6%) and medium sized (23.2%) enterprises. Despite Canada's strength in AI, only 4% of Canadian enterprises actually used this technology in 2017.

According to the 2017 Survey of Innovation and Business Strategy (SIBS):

- Around 4 in 10 firms in Canada used some type of advanced technology in 2017.
- Small firms were 3 times less likely to adopt AI than large firms.
- Small firms were 1.5 times less likely to adopt Internet of Things (IoT) than large firms.

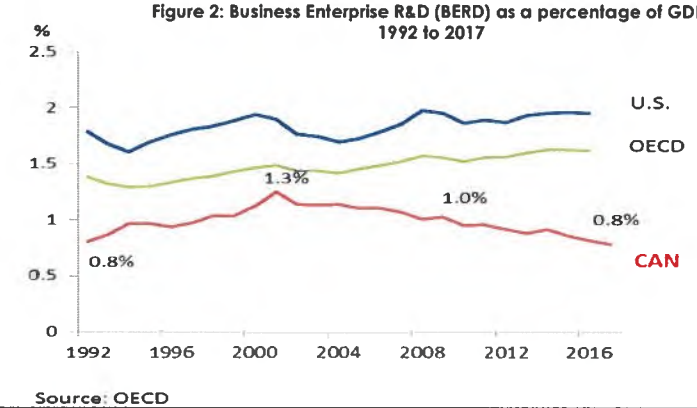
Source: Statistics Canada.

The low uptake of digital technologies by Canadian firms, particularly smaller firms, might be partly explained by the perception that the high levels of risk and uncertainty associated with them could outweigh their potential benefits. According to the OECD, digital technologies as General Purpose Technologies (GPTs) are still relatively young, far ranging and quickly changing. Their current and future development is uncertain and therefore represent a source of risk for those firms looking to adopt such technologies. Regardless, Canadian firms need to adopt advanced technologies, because are increasingly becoming necessities in order to remain competitive in the digital economy.

R&D – A Key Intangible Asset

Capital investment is no longer confined to just machinery, equipment and buildings. Modern capital accumulation increasingly depends on intangible assets, such as research and development (R&D), software, databases, branding, patents, and organizational systems. Among various types of intangibles, business expenditure on R&D (BERD) is considered the key input into high value-added forms of innovation. Accordingly, BERD is thought to be an important driver of long-term and sustainable economic growth. However, despite generous government support, Canada's BERD over GDP has been declining since the early 2000, with Canada's ranking slipping from 16th in 2006 to 23rd in 2017 among OECD countries.

Figure 2: Business Enterprise R&D (BERD) as a percentage of GDP, 1992 to 2017

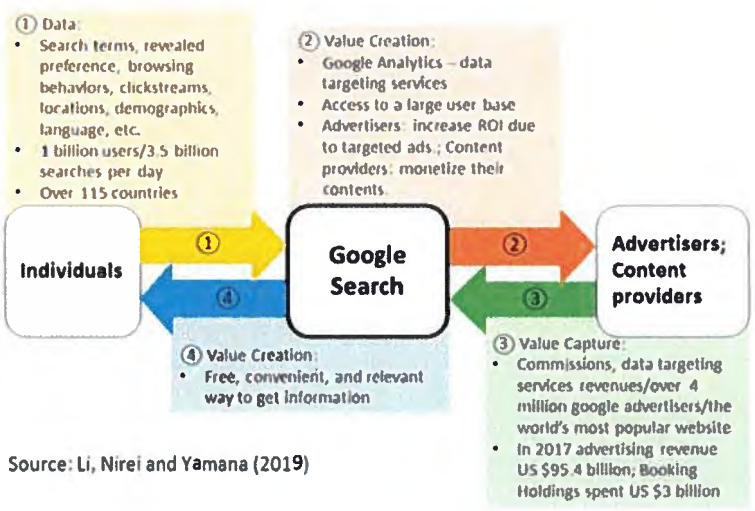


Source: OECD

Investment in Data

Digital technologies are the new GPTs driven by data. They affect all sectors of the economy, from the development of software components in car manufacturing to the customization of products for consumers. Data is becoming a core input in a firm's production function and, since it is intangible, it is unlike any other input. Data is fluid and readily available at a low marginal cost. Meanwhile, it is not subject to physical constraints like distance or national boundaries, nor does it suffer from wear and tear like tangible capital. Data is also an input to the innovation process, with a broadening net of sources, including personal data (e.g., gathered from social media websites, transactions, or patient data), business and innovation data (e.g., produced by companies internally), and government and public research data (e.g., government-collected personal data).

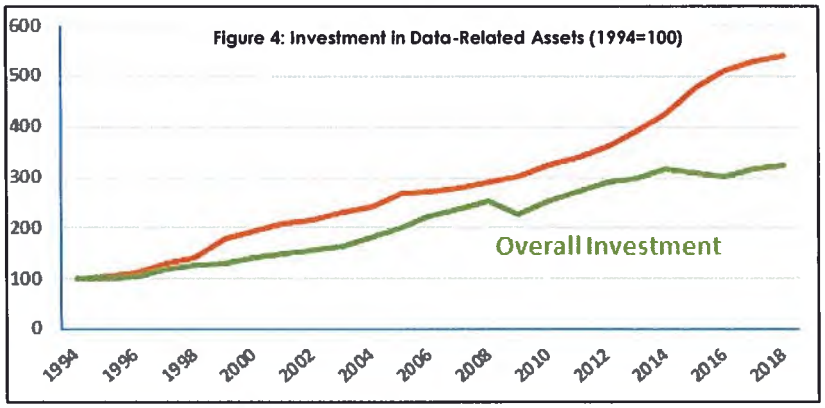
Figure 3: Illustration of a Platform Model of Value Creation



Data as a core input to production is highlighted by its capacity to: create new markets by re-selling data; disrupt traditional markets, as demonstrated by the introduction of rideshare companies like Uber or Lyft; and, potentially modify business models in all sectors of the economy, as firms grapple with rapidly expanding industries and a shift to intangible-intensive production.

The increasing prevalence of data business models of firms highlights the need for effectively valuing data. The proliferation of online platforms, whether it be for e-commerce (e.g., Amazon), online sharing (e.g., AirBnB), or conducting searches (e.g., Google), indicates a shift to "asset-light" companies whose activities are centered on data with less of a physical footprint. Indeed, online platform companies are essentially "data companies" that not only collect data through online interactions with their customers, but also create data based on data flows within the online platform network and through interactions with third parties[11]. Recent experimental estimates from a Statistics Canada study[12] shows the extent of this increasing importance of data (See Figure 4). According to the study, Canadian investment in data, databases and data science was estimated as high as $40 billion in 2018 – greater than the annual investment in industrial machinery, transportation equipment, and research and development, and representing approximately 12% of total non-residential investment. While

Figure 4: Investment in Data-Related Assets (1994=100)



[11] Li et al. (2019). "Value of data: There is no such thing as a free lunch in the digital economy". US Bureau of Economic Analysis.
[12] Statistics Canada (2019). "The Value of Data in Canada: Experimental Estimates".

there is no international benchmark yet to compare Canada's performance, the Bureau of Economic Analysis is expected to release a comparable estimate for the US shortly.[13]

Better understanding and harnessing the power of data is not only important for Canadian firms, but also for policy makers who need to grasp the new operational dynamics faced by Canadian firms. To promote informed discussions, more robust information is needed on data and the role it plays in business. In particular, the government needs to help firms transition away from operating in a physical capital world towards an environment where intangibles, led by data, play a more important role.

EXTERNAL DRIVERS

Emergence of a Platform Economy and Inter-sector Connectivity

The increasing importance of data in the production process has led to the emergence of a platform-based economy. Data allows a company to build a platform based on several products and services (e.g., devices and services based on Google's Android and Apple's iCloud), instead of focusing on a particular product sold in a specific local market. Similarly, consumers do not have to focus on a single good or service. They can utilize a platform encompassing a multitude of products, including niche items, which can be easily introduced to consumers or microfirms joining the platform. This leads to a significant expansion of the array of goods and services available for consumption, while reducing frictions and barriers in the interactions between businesses and consumers, ultimately resulting in a more fluid and efficient matching of demand and supply. However, this also implies platforms could redefine markets in a way that might not correspond to national or local markets, thereby affecting how we view competition.

As of July 2018:

- 12 ride-hailing firms (including Uber, Didi-Chuxing, etc.) globally, each with a market valuation of over $1 billion.
- Collectively these 12 firms have a market valuation of nearly $160 billion.
- None are headquartered in Canada, although three (Uber, Lyft and Taxify) operate in the country.

Sources: Kulkarni (2018) , Brail and Donald (2018)

The new digital economy, driven by the data, has further amplified the declining relevance of location-based markets, which began with globalization. In particular, having data as a major component allows products and services to flow across borders more quickly, because advancements in ICT means that the tasks associated with handling data (e.g., collection, aggregation, analysis, storage, use, monetization) can be done virtually anywhere.

An important feature of a platform economy is that products and services driven by data span a number of different industrial sectors. That means a single large firm could become multi-sectoral by exercising control over an increasingly large range of products and services that cross the boundaries dividing sectors. For example, while there was little overlap between automobile producers and digital or electronic goods producers (e.g., computers and televisions) in the past, the current wave of automobile production involving driverless cars has led to digital technology firms playing a leading role, as evidenced by the fact that firms like Google, Uber and Apple are leaders in the testing of driverless cars. Meanwhile, traditional automakers like Ford and General Motors have started venturing into the technology sector as part of their own work on driverless cars, which they intend to use to enter the ride-sharing market. The sector overlap also extends to clean technology, as Tesla, a leading producer of electric cars, has existing models already outfitted with auto-driving features.

[13] Statistics Canada and Bureau of Economic Analysis have been jointly developing the statistical approach to the experimental estimate on data.

The emergence of a platform economy and increasing inter-sector connectivity will have a profound impact on the overall competitive dynamics of an economy, not only in terms of how we measure competition, but also because competition polices might have to adapt to the new reality. For example, if global conglomerates increasingly expand their market shares, then a new competition policy for the digital economy may have to strike the right balance between allowing Canadian firms to grow larger and ensuring a competitive domestic marketplace. Also, the emerging drivers of the competitive dynamics need to be more explicitly accounted for in order to develop an effective competition policy.

The new digital economy clearly poses challenges for Canadian firms; however, there could also be opportunities for growth. For instance, the declining importance of physical distance puts Canadian firms in a better position to overcome some of the geographical obstacles that they typically face. This also means they might be able to leverage their small size and open nature to thrive in niche segments of the global market.

Regulations

Good regulations play an important role in meeting policy objectives when it comes to economic growth. That said, the nature of market dynamics is different in the new digital economy, meaning that the regulations that govern the marketplace have to reflect these new realities. In particular, the growing importance of data and other intangibles, as well as increasing sector-interconnectivity and the declining relevance of local markets, mean that past regulations based on conventional market dynamics, where a firm enters a local market and then grows by accumulating physical assets, might not be effective.

In general, Canada's performance in competitive regulation is mixed. Among OECD countries, while Canada performs well in a few areas pertaining to the government's control over the economy (1st in administrative burdens, 4th in government involvement in network sectors), it performs poorly in a number of other areas, particularly with respect to barriers to trade and investment (30th).[14]

The main challenge when it comes to regulating in the digital economy is to establish the right balance between the risks that come with new ideas and the risks of stifling them. Traditional regulations are stable in nature, which is well-suited for industries where the pace of change is slow and the environment is predictable. However, the emergence of the digital economy is challenging this approach, as traditional regulations are unable to adequately adapt and address emerging, fast-growing industries, or technologies with fluid boundaries and low barriers to entry. This is leading to a shift to "anticipatory" regulation, whereby regulations are designed around the concept of functionality as opposed to legacy technologies or industry sectors. That is to say, they focusing on the ex post enforcement of broad rules based on what the desired outcome looks like, instead of detailed ex ante prescriptions.[15] Regulatory "sandbox" is another good example of a new approach for testing and enabling emerging technologies in a closed environment.

In Canada, it is important to adjust the regulatory framework so as to prevent social harms (e.g., loss of privacy, cyber-vulnerability, levelling the playing field between digital and traditional firms) without undue negative impacts on the functioning of the digital economy. Regulations will need to be agile, as the array of new emerging products and services is hard to predict, and focus on outcomes and broad principles.

Trade and FDI

Digital transformation has implications for the very nature of trade. Not only is there a growing prevalence of digitally delivered trade, but digitalization also enables traditional trade through enhanced connectivity by facilitating transactions, coordinating global value chains, diffusing ideas, and by allowing economic actors to trade more directly. The growing

[14] OECD Product Market Regulation 2018.
[15] Eisenach and Soria (2016). A New Regulatory Framework for the Digital Ecosystem. GSM Association and NERA Consulting.

prevalence of online platforms and marketplaces has effectively removed the need for physical intermediaries to connect supply and demand. As such, firms, particularly smaller ones, can now more easily bring new products and services to a larger number of digitally-connected customers around the world. Digitally delivered services, such as online banking, are also creating new types of bundled goods and services (i.e., services embedded in goods).

Digitalization is also affecting how FDI decisions are made. For example, the internet is transforming the international operations of multinational enterprises (MNEs) by making a physical presence overseas less fundamental, thus, lightening the international footprint of international production on the part of MNEs. A lighter international footprint, combined with limited investment in tangible assets and large volumes of international sales, provides fertile ground for financial and tax-driven patterns of investment. That is to say, resources are only being partly used to finance foreign productive capacity, with the majority of them being channelled into non-core operations, likely for tax optimization reasons.[16]

IMPLICATIONS FOR ISED

Canadian firms are facing a global economy that is rapidly being redefined by digitalization. Consequently, ISED needs to adopt a new approach to developing polices and programs in order to help Canadian firms compete in this new economic environment. While traditional drivers of growth are still relevant in this time of transition, we have to look ahead and consider the new realities of the digital economy.

ISED is leading government-wide efforts in this regard as part of its implementation of the Digital Charter to help modernize Canada's regulatory framework. This means ensuring marketplace frameworks are fit for purpose and are adapted to the digital economy. This involves consideration of data in competition enforcement, the enhanced role of intellectual property and the importance of intangible assets, updating privacy laws to reflect the new role of data in creating value in the digital economy; investing in digital infrastructure to ensure all Canadians have access to critical digital services; and, modernizing the national statistical system to be more responsive to the increasing demands for data, while maintaining the trust of Canadians in terms of how data are collected and used.

These efforts represent an important base from which ISED can continue to lead the development of policies and programs, as Canadian firms continue their transition to the digital economy. Not only do we have to look beyond the traditional factors of growth and take new realities into account, we also need to stay agile in order to efficiently respond to changing environments.

For further information about this document contact the author at the following e-mail address or telephone number:	Hankook Kim *Innovation, Science and Economic Development* (613) 762-4336 Hankook.Kim@canada.ca

[16] Casella and Formenti (2018). FDI in the Digital Economy: A Shift to Asset-light International Footprints. Transnational Corporations: 25(1).

The Productivity Advantage of Multinationals in Canada*

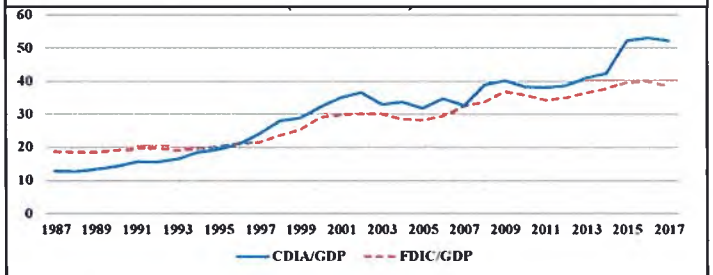
HIGHLIGHTS

- Canadian multinationals are as productive as foreign multinationals. Together, both types of multinationals are on average about 23 percent more productive than non-multinationals.
- The path for Canadian firms to become a multinational involves both selection and learning effects. In particular, before becoming a multinational, Canadian multinationals are more productive than others (i.e., selection), and they become even more productive after having become a multinational (i.e., learning).
- The productivity advantage of multinationals is largely driven by their investment in research and development.

IMPORTANCE OF MULTINATIONALS IN THE CANADIAN ECONOMY

Multinationals play an increasingly important role in almost all economies. Canada is one of the most active nations, as evidenced by a substantial increase in its foreign direct investment in Canada (FDIC) and Canadian direct investment abroad (CDIA) since 1990 (Figure 1). The literature showed that they are more innovative, and more productive than non-multinationals. They also pay higher wages.

Figure 1: Inward and Outward FDI in Canada (percent of GDP)



Source: Statistics Canada

To examine the relative performance of multinationals in Canada, this study constructs a rich micro data from several administrative micro data files at Statistics Canada, which covers all industries over 2000-2014. Using this rich

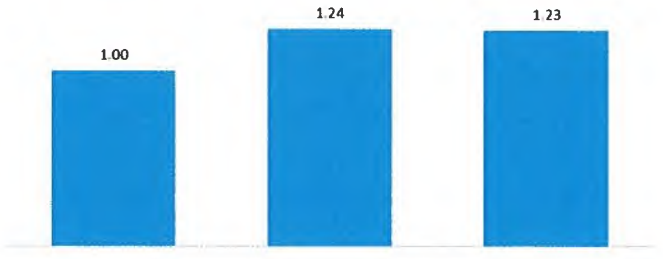
*This is a summary of the research paper, *The Productivity Advantage of Multinationals: Canadian Evidence* (September 2019) by Jianmin Tang and Weimin Wang.

micro data, the study estimates the productivity advantage of multinationals, including the advantage before becoming a multinational (selection effects) and the advantage Canadian multinationals enjoy once they become one (learning effects). Further, the study investigates whether the multinational's investment in R&D play an important role in the superior productivity performance of multinationals.

PRODUCTIVITY ADVANTAGE OF MULTINATIONALS

The study shows that (1) Canadian multinationals are as productive as foreign multinationals, and (2) multinationals are on average about 23 percent more productive than non-multinationals (Figure 2). In addition, the study finds that the productivity advantage of multinationals is larger in the service industries (about 25 percent) than in the goods producing industries (20 percent).

Figure 2: Multifactor Productivity Performance by Multinationality (Non-multinationals = 1.00)

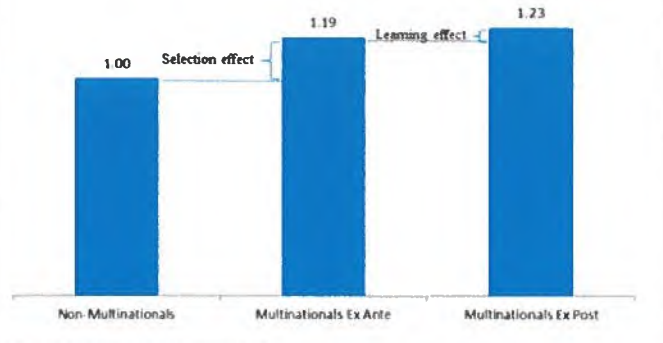


Is the productivity advantage of multinationals mainly due to the selection effects or the learning effects? In other words, are multinational firms more productive before they become multinationals or do they only become more productive after the fact?

The FDI literature postulates that firms must possess firm-specific advantages to operate in a foreign environment where businesses may have additional costs due to operating in new markets as a result of differences in cultural norms, weaker association with the local community, and challenges in management due to the greater distance. Only the most productive firms are able to overcome these "foreignness" factors and afford the cost to operate profitably in foreign markets. This ex ante productivity advantage is called **selection effects** in the literature.

After becoming a multinational, firms can learn from their foreign operations and improve their productivity as a result. First, by going beyond the domestic market, multinationals can achieve economies of scale while ideas, management practices or technologies developed by foreign affiliates may be used freely by their counterparts in Canada. Second, the strategies deployed by firms operating in different international markets often provide a more flexible production organization that can better deal with both supply and demand shocks, which would add to the firms' competitive advantage. Third, the presence of physical operations in a foreign market could allow firms to enhance their knowledge of local business opportunities, which could provide them with the access and opportunity to subsequently transfer location-specific knowledge. Finally, firms exposed to international markets forces face vigorous global competition with best-performing companies, and as a result, they face strong incentives to improve efficiency through product, process, or organizational innovation while reducing managerial slack. This growth in productivity of a multinational firm subsequent to becoming one is called **learning effects** in the literature.

Figure 3: Ex Ante and Ex Post Multifactor Productivity Performance of Multinationals (Non-multinationals = 1.00)



The study sheds light on the path for Canadian firms to become a multinational, where they experience both

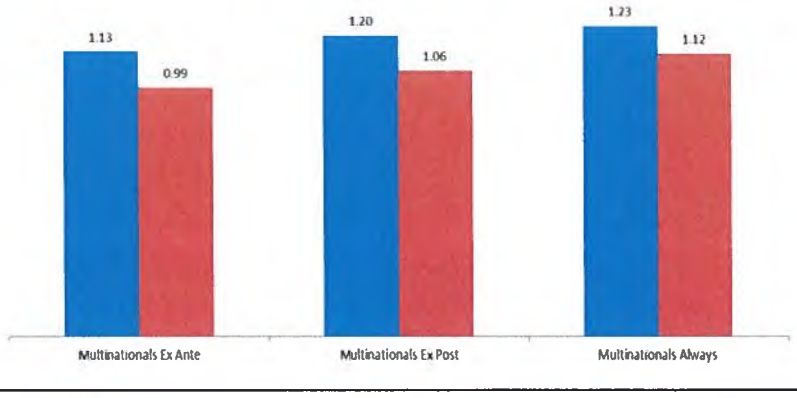
selection and learning effects. In particular, the results show multinationals are 19 percent more productive than non-multinationals before becoming multinationals and enjoy an additional improvement of 4 percent in productivity after becoming one. Overall, this leads to Canadian multinationals enjoying a 23 percent premium in productivity as compared to non-multinationals, which is on par with the advantage enjoyed by foreign multinationals (Figure 3).

ROLE OF R&D IN PRODUCTIVITY ADVANTAGE OF MULTINATIONALS

Why are multinationals more productive than non-multinationals? A popular explanation consistent with extensive empirical evidence on the positive impacts of research and development (R&D) on productivity is that multinationals may have advanced firm-specific technologies as underpinned by their R&D investments. R&D investments can be part of a strategy deployed by firms to develop firm-specific technological advantages. Not only is R&D associated with innovative products/services and production process, a firm's intense efforts in R&D could also lead to a greater use of intellectual properties to protect its investment, giving itself an edge in both home and foreign markets. Further, more R&D could enhance a firm's absorptive capacity, leading to a better ability to learn from both domestic and foreign markets.

The results in this study show multinationals are more R&D intensive than non-multinational, especially before they become multinationals. Further, multinationals seem to have an advantage in extracting productivity benefits from their R&D efforts, and this ability to generate higher returns from the R&D investment can largely explain the overall productivity advantage. Results from the econometric model[17] show that, together, both types of R&D effects can explain all of the productivity advantage of multinationals before becoming one and 70 percent of the productivity advantage of multinationals after the fact (Figure 4).

Figure 4: Learning and Selection Effects of Multinational with and without R&D Effects (Non-multinationals = 1.00)



There could be a number of factors behind a better ability of multinationals to exploit R&D investment. Multinationals could be in a better position to generate higher returns from R&D due to their flexible cross-country production structure, larger markets for their products, and access to foreign advanced technologies and resources. Other firm-specific factors could include their superior managerial skills and capacity for strategic thinking, which may also influence their decision to become multinational.

[17] The econometric model allows not only to capture the productivity effect from firms' differences in R&D effort, but also the productivity effect from firms' differences in ability to generate returns from R&D investments.

CONCLUSION

This study provides empirical evidence highlighting the path for a Canadian firm to become a multinational. The findings suggest Canadian firms improve their productivity before becoming a multinational and continue to do so even after having become one, ultimately enjoying a similar productivity advantage as foreign multinationals. Further, the results show investment in R&D plays a critical role in improving productivity for future and current Canadian multinationals, with such firms not only making more investment in R&D but also extracting greater returns in higher productivity from their investments. These provide important insights for developing policy designed to help Canadian firms grow and join the global marketplace. Firms can learn from their foreign operations or affiliates and improve their performance after becoming a multinational. However, to enter foreign markets, firms need to improve the productivity performance beforehand by investing in key assets such as R&D.

For further information about this document contact the author at the following e-mail address or telephone number:

Jianmin Tang,

Innovation, Science and Economic Development

Jianmin.Tang@canada.ca

+1 (613) 220-0155

INSIGHTS DATA TABLE

Monthly Economic Indicators

		Month-over-month growth (at monthly rates)			Q-o-q growth	Year-over-year growth	
	Reference Period	Latest month	Prev. month	2 Months before	2019Q3	2018	2017
Mfg sales (current $)	Nov '19	-0.6	-0.2	-0.1	-1.3	5.4	6.0
Mfg sales (constant $)	Nov '19	-0.8	0.1	-0.4	-1.0	2.1	4.1
Retail trade (current $)	Nov '19	0.9	-1.1	0.0	0.3	2.9	7.1
Retail trade (chained $)	Nov '19	0.7	-1.3	0.0	0.3	0.9	5.7
Real GDP	Oct '19	-0.1	0.1	0.1	0.4	2.2	3.2
-Services	Oct '19	0.0	0.2	0.1	0.7	2.1	2.8
-Manufacturing	Oct '19	-1.4	-0.4	0.8	-0.5	2.5	3.7
Exports (bop) (current $)	Nov '19	-1.4	-0.4	-1.4	-2.3	6.3	5.4
Imports (bop) (current $)	Nov '19	-2.4	0.6	-1.9	-0.7	5.7	4.9
All-items CPI	Dec '19	0.0	-0.1	0.3	0.3	2.3	1.6
All-items CPI excluding food and energy	Dec '19	-0.2	-0.3	0.5	0.5	1.9	1.6
LFS employment (Δ in 000s)	Dec '19	35.2	-71.2	-1.8	110.6	195.8	417.4
Unemployment rate (%)	Dec '19	5.6	5.9	5.5	5.6	5.8	6.3
US employment (Δ in 000s) (CPS)	Dec '19	267.0	-8.0	246.0	1,150.0	2,848.0	1,761.0
US unemployment rate (%)	Dec '19	3.5	3.5	3.6	3.6	3.9	4.3

Financial Indicators

			Monthly average			Annual average	
	Reference period	Current value	Latest full month	Prev. month	2 Months before	2018	2017
Bank rate (%)	Jan 22 '20	2.0	2.0	2.0	2.0	1.7	1.0
Exchange rate	Jan 22 '20	131.2	131.7	132.4	131.9	129.6	129.8

Quarterly Economic Indicators

		Quarter-over-quarter growth (at annual rates)			Year-over-year growth	
	Reference Period	Latest quarter	Prev. quarter	2 Quarters before	2018	2017
Real GDP	2019Q3	1.3	3.5	0.8	2.0	3.2
Final consumption expenditure	2019Q3	1.4	1.0	2.5	2.4	3.2
Gross fixed capital formation	2019Q3	9.9	-2.2	6.3	1.2	3.6
-Machinery & equipment	2019Q3	7.0	-21.8	42.1	4.7	9.7
Exports	2019Q3	1.5	12.9	-3.3	3.1	1.4
Imports	2019Q3	0.1	-3.5	8.1	2.6	4.2
Final domestic demand	2019Q3	3.2	0.3	3.3	2.1	3.3
Labour productivity	2019Q3	0.9	0.3	2.0	-0.2	2.2
Unit labour cost	2019Q3	4.2	2.6	4.0	2.4	0.5
Industrial capacity utilization (%)	2019Q3	81.7	83.3	81.0	83.0	81.6
Real US GDP	2019Q3	2.1	2.0	3.1	2.9	2.4