Centre for International
Governance Innovation

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Rethinking Industrial Policy for the Data-driven Economy

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Table of Contents

About the Author

Senior Fellow Dan Ciuriak joined CIGI's Global Economy Program in April 2016, focusing on the innovation and trade research theme. At CIGI, Dan is exploring the interface between Canada's domestic innovation and international trade and investment, including the development of better metrics to assess the impact of Canada's trade agreements on innovation outcomes. Based in Ottawa, Dan is the director and principal of Ciuriak Consulting, Inc.

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About the Global Economy Program

Addressing limitations in the ways nations tackle shared economic challenges, the Global Economy Program at CIGI strives to inform and guide policy debates through world-leading research and sustained stakeholder engagement.

With experts from academia, national agencies, international institutions and the private sector, the Global Economy Program supports research in the following areas: management of severe sovereign debt crises; central banking and international financial regulation; China's role in the global economy; governance and policies of the Bretton Woods institutions; the Group of Twenty; global, plurilateral and regional trade agreements; and financing sustainable development. Each year, the Global Economy Program hosts, co-hosts and participates in many events worldwide, working with trusted international partners, which allows the program to disseminate policy recommendations to an international audience of policy makers.

Through its research, collaboration and publications, the Global Economy Program informs decision makers, fosters dialogue and debate on policy-relevant ideas and strengthens multilateral responses to the most pressing international governance issues.

Acronyms and Abbreviations

AI	artificial intelligence
CPTPP	Comprehensive and Progressive Agreement for Trans-Pacific Partnership
DARPA	Defense Advanced Research Program Agency
FDI	foreign direct investment
FIRA	Foreign Investment Review Agency
IoT	Internet of Things
IP	intellectual property
M&A	mergers and acquisitions
OECD	Organisation for Economic Co-operation and Development
SBIR	Small Business Innovation Research
R&D	research and development
WTO	World Trade Organization

Executive Summary

This paper reviews industrial policy in theory and historical practice. It makes the case for a fundamental reframing based on the centrality of data to the data-driven digital economy, the various roles that data plays in this economy (as a medium of digital transactions, as intangible capital and as infrastructure of a digitized economy), and the heightened scope for market failure in the data-driven economy. A number of points to guide the formulation of industrial and innovation policy in the knowledge-based and data-driven digital economy are suggested.

Participation in the data-driven economy requires access to truly big data. Small open economies will need to scale up data in order to scale up companies. The acceleration of the pace of change and the concentration of wealth in the data-driven economy alters the set of investments with risk-return metrics that the private sector will engage. Public policy must support projects that have social merit, but which private capital leaves on the table, and which would be screened out by conventional criteria for industrial policy interventions by the public sector. Foreign direct investment (FDI) policy must take the impact of inward mergers and acquisitions (M&A) investment on the dynamism of innovation systems into account, in particular where such takeovers would have anti-competitive effects or materially reduce knowledge spillover benefits within a country's innovation system. The rent-based business model of the data-driven economy makes asset accumulation essential for national wealth creation. Policy must therefore shift from focusing on activity to building a rent-generating stock of technology assets. Possible measures include adopting a retention policy for domestically developed knowledge capital produced with public funding support; giving appropriate weight to the implications for a country's stock of technology assets of FDI, including the potential loss of technology through inward M&A-type FDI and potential gain of technology through outward FDI; and ensuring freedom to operate for domestic technology firms through, for example, a state patent fund to address issues related to patent proliferation, in particular given the arms race in the artificial intelligence (AI)/machine learning space. International commitments need to preserve policy space to implement a data strategy to secure a foothold in this emerging economy. As part of their data strategies, countries should assess the market value of data generated in the exercise of public sector governance and data generated in their public space; put in place procedures to capture data and regulate its capture; and use procurement to develop new capabilities in the private sector.

Introduction and Overview

Industrial development and innovation are two sides of the same coin. The development, acquisition and adaptation, and application of technology — which is to say, innovation — has always been the cornerstone of industrial progress. However, historically, industrial *policy* has not generally been synonymous with innovation policy; instead, it has been associated with, among other things, protection of sunset industries, promotion of prestige sectors or national champions, and "gap filling" to compensate for inadequate private sector development. As a result of the mixed record of success of past practices, industrial policy has acquired considerable baggage, not least of which is wide acceptance in both academic and policy circles that public sector interventions in this policy space should be restricted to the development of the economic infrastructure to facilitate doing business, while leaving decisions about the allocation of capital to the private sector.

With the digital transformation, the distinction between industrial and innovation policy effectively disappears as innovation reshapes the industrial landscape. Moreover, the criteria for public sector intervention change in line with the shifts in the economic characteristics and behaviour of the data-driven economy that is being ushered in by the digital transformation (Ciuriak 2018).

This paper first provides a brief overview of how industrial/innovation policy has been framed, with a focus on modern practice in the advanced economy members of the Organisation for Economic Co-operation and Development (OECD) and in Canada in particular. It considers whether the strong general prejudice against activist industrial policy is supported by the evidence and concludes that for Canada it is not.

Having dispelled the ghost of industrial policy past, the paper then makes the case for a fundamental reframing of industrial/innovation policy based on the centrality of data to the data-driven digital economy, the various roles that data plays in this economy (as a medium of digital transactions, as intangible capital and as infrastructure of a digitized economy) and the heightened scope for market failure in this economy. Against this background, it sets out some guidelines for industrial/innovation policy in the knowledge-based and data-driven digital economy, addressing in turn:

- the challenge of scaling up the data accessible by Canadian firms;
- the implications for public policy of the rent-based business model of the knowledge-based and data-driven economy;
- the implications for public versus private investment roles in the technology sphere;
- the implications for policy regarding FDI in the technology sector; and
- the approach to trade agreements, and in particular government procurement, in providing policy space for industrial strategy in the digital age.

Background and Historical Context

Industrial Policy in Theory and Practice

The conventional case for industrial/innovation policy rests on the existence of externalities — costs and benefits that do not figure into the expected profits of firms or the utility obtained by consumers. Externalities — both positive and negative — are associated with virtually every economic activity. Accordingly, there is broad scope for industrial interventions under the conventional framing of the issue. In addition, a wide range of ad hoc reasons have been used to support specific policies in particular contexts, including national security, food security, response to macroeconomic shocks, regional economic difficulties and others.

The positive case for industrial policy has traditionally rested on four main theoretical arguments, each of which is based on market failure:

- Positive local externalities result in underinvestment by private actors, supporting public investment to compensate. The most common example is cluster policy, which seeks to emulate the success of vibrant innovation clusters such as California's Silicon Valley.
- Increasing returns to scale create opportunities for nations to capture international rents through strategic trade policies.
- Steep learning curves in the early stages of developing industrial processes, and the transferability of technical and managerial experience obtained in producing particular goods, support industrial policies based on "learning by doing" or "infant industry" arguments.
- For complex goods or projects, a range of complementary inputs and supporting services that are the outputs of other firms or industries are required. The possibility of "missing markets" creates a coordination problem for generating industrial development in developing countries. Industrial policy steps in to address this coordination problem.

The case for governments *not* to act on externalities (whether to regulate to restrict negative externalities or to subsidize activities with positive externalities) is threefold:

- significant negative externalities can be resolved by private contracting between the parties causing incidental harm to third parties (an influential argument developed by Robert Coase);
- governments "can't pick winners," so any attempt to capture potentially significant positive externalities will result in wasteful expenditures; and
- governments lack the information to accurately address minor externalities (negative or positive) and the cost of attempting to do so exceeds the benefits.

Historically, industrial policies were widely used. With the neoclassical ascendancy in the 1980s, the case against government intervention generally prevailed and was reinforced by the General Agreement on Tariffs and Trade/World Trade Organization (WTO) Agreement on Subsidies and Countervailing Measures, which makes the implicit assumption that government intervention is a distortion rather than a correction. In the advanced countries, this led to widespread reframing of industrial policy to focus on support for industrial development in general (infrastructure and so on — so-called "horizontal" or "soft" industrial policy) and avoidance of interventions that could be seen as attempting to pick winners in specific sectors (so-called "vertical" or "hard" industrial policy) and, hence, liable to be targeted by countervailing duties as a specific subsidy, if the policy support had measurable success.[1]

To be sure, notwithstanding the prevailing orthodoxy, governments in the advanced countries continued to intervene with subsidies in major industries, such as civil aviation. As knowledge-based economies developed, industrial policy evolved into innovation policy, and governments directed their support into new high-technology areas, such as nano technology, solar, electric cars and so on, although support was often distorted to fit into "horizontal" configurations (for example, tax credits for research and development expenditures in general).

More recently, dissatisfaction with economic outcomes (waning business dynamism or "secular stagnation" in the advanced countries and poor developmental results in many emerging markets) together with apparently successful deployment of industrial policy in East Asian economies, such as China and South Korea, led to widespread reconsideration of industrial policy (*The Economist* 2010).[2] A new orthodoxy failed to emerge, however, and we enter the data-driven economy era with an ambivalent bottom line on industrial and innovation policy.

1 Ann E. Harrison and Andres Rodríguez-Clare (2010) and Shanta Devarajan and Marilou Uy (2009) discuss the horizontal/vertical distinctions, referring to horizontal policies as soft industrial policies and vertical policies as hard industrial policies.

2 For a review of the literature on the revival of industrial policy, see Dan Ciuriak (2013).

Canada's Historical Use of Industrial Policies

Historically, Canada's economy evolved behind protective tariff walls and with the support of government policy activism. This included the establishment of numerous gap-filling government business enterprises (Canada's term for state-owned enterprises) in the backbone infrastructure sectors, such as the Canadian National Railway, the Canadian Broadcasting Corporation, Trans-Canada Air Lines (which later would become Air Canada) and the St. Lawrence Seaway Authority. Canada also intervened through regulation in areas such as cultural industries and telecommunications; through the Defence Production Sharing Agreement with the United States; through the nationalization of Canadair (twice); and through financial support delivered by, *inter alia*, the Industrial Development Bank (later the Business Development Bank), the Canada Mortgage and Housing Corporation and the Canadian Commercial Corporation.

As international competition increased in the postwar period, Canada was widely viewed as suffering from a number of problems: an excessively domestic orientation due to still-high tariff protection and lack of export mandates for foreign-controlled branch plants; lack of competitiveness due to too low a scale of operation; poor management because of too little competition; and inadequate innovation, which was also attributed to high levels of foreign ownership.[3] The solutions adopted were trade liberalization (including managed trade in the case of the 1965 Auto Pact) to gain access to scale economies through exporting, but also a review of inward FDI through the Foreign Investment Review Agency (FIRA).

At the beginning of the 1980s, all this policy activism resulted in Canada having 67 parent Crown corporations, which, in turn, had 128 wholly-owned subsidiaries with combined assets valued at CDN$50 billion. Of these, 32 wholly-owned Crown corporations, including 19 belonging to the federal government, were in the *Financial Post*'s list of top 500 Canadian corporations. In addition, the federal government had significant (more than 10 percent) equity positions in an additional 22 companies and portfolio investments

3 Ronald J. Wonnacott (1975) surveys the literature from this period. On the contemporary perspectives on FDI, see the budget speech delivered by the Hon. Walter L. Gordon, minister of finance (Gordon 1963).

in more than 100 companies and affiliates with a total asset value of CDN$8 billion through its 47 percent controlling interest in the Canada Development Corporation (Laux 1993).

Under the government of Brian Mulroney, Canada followed the contemporary trend in the advanced economies and substantially reduced its industrial policy interventions. Most Crown industrial assets were privatized and the FIRA was replaced by Investment Canada, which had a mandate to promote rather than screen inward investment. Within the federal government, the narrative went that Canada's progress up the development ladder warranted greater reliance on private markets and a shift toward indirect or horizontal policies for economic development. The new policy orientation, which was continued by the governments of Jean Chrétien, Paul Martin and Stephen Harper, met with consistent approval in international peer reviews (for example, by organizations such as the OECD), with the main criticisms focusing on the remaining modest derogations from open trade and investment that Canada continued to maintain, such as screening of inward FDI. How well did it in fact work?

Canada's Economic Performance

Over long history, Canada has converged toward the US level of per capita income, albeit with many ups and downs. The Madison Project Database provides consistent per capita GDP figures for Canada and the United States since 1870. Canada's per capita GDP on trend increased from about 70 percent on average in the pre-1900 period to about 84 percent in the late 1970s, the highest ratio Canada has ever sustained by this measure.[4]

This record of trend convergence was not evidently sustained post-1980 when Canada reoriented its industrial policy. The period of dismantling of Canada's industrial policy assets under the Mulroney government saw a reversal of the observed trend: in purchasing power parity terms, Canada's GDP per capita fell from about 90 percent at the beginning of the Mulroney reforms to the low 80 percent range at the end of his term, and has stayed in the latter range ever since, through the Chrétien and Martin years, the Harper years and to the present under Justin Trudeau's government, through booms and busts and financial crises (see Figure 1). Canada's multifactor productivity measure also moved sideways during this period (Medhora 2017).

Notably, the period since the early 1990s was also one in which Canada focused its industrial policy on innovation, seeking to capitalize on its strong capacity for knowledge-based growth with a knowledge-based economy strategy.[5] However, consistent with the sideways movements on bottom-line indicators, innovation performance received consistently mediocre or poor marks, despite consistently high scores on innovation inputs, even as the technology sector went through boom, bust and revival.

Mapped against Canada's relative economic performance, the era of activist industrial policy produced convergence to the US level; the period since has not. In Canada, as elsewhere, following the great recession of 2008-2009, lacklustre performance triggered renewed interest in industrial policy. In Canada, as elsewhere, a compelling new vision has not to date emerged.

Canada's rebuilding technology sector played only a marginal role in the wave of disruptive technological change since the global crisis of 2008-2009. With the next wave building, under economic conditions that promise to differ sharply from those of past eras, Canada needs to rethink industrial policy to ensure that Canada surfs the wave rather than being inundated by it.

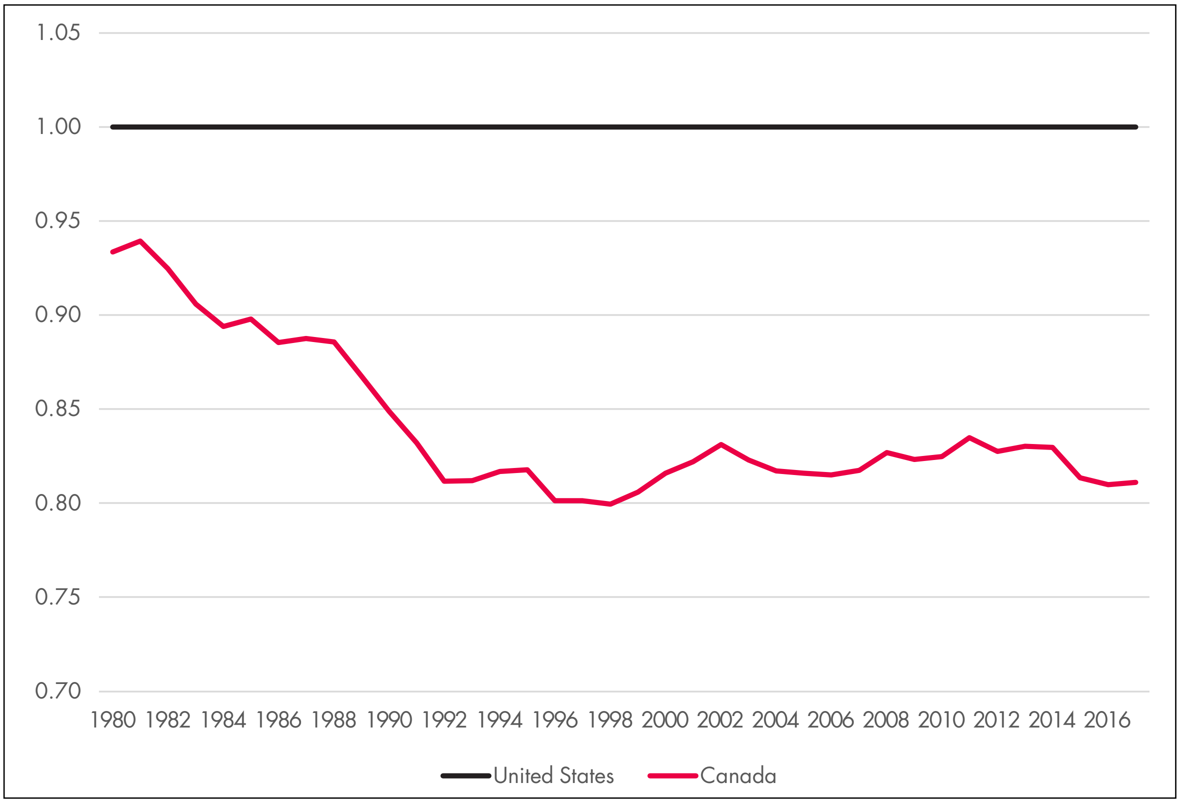
Reframing Industrial Policy for the Data-driven Economy

The Government of Canada has posed a number of questions for its national consultations on digital and data transformation. These concern digital adoption by businesses, building an innovation ecosystem and promoting inclusiveness by citizens, young and old, in the data-driven economy being created through the digital transformation.

4 Groningen Growth and Development Centre, www.rug.nl/ggdc/historicaldevelopment/maddison/releases/maddison-project-database-2018.

5 The first mention of a knowledge-based-economy strategy in Government of Canada policy research was in the mid-1990s.

Figure 1: Canadian per Capita GDP as Percentage of US per Capita GDP, 1980–2017



Data source: International Monetary Fund, World Economic Outlook Database, April 2018.

Questions tend to frame the scope of responses. The above questions point to the following answers:

- If companies are not engaging in the digital transformation, they must be facing barriers. The enumeration of these barriers will likely include: business culture resistance; lack of awareness or understanding of digital trends/application to their business and business processes (including how to activate and capitalize on data resources); lack of talent to undertake a digital transformation (including the strategies to get there from here); or lack of capital resources to finance the upfront fixed costs.
- Building an innovation ecosystem involves policies aimed at expanding the number of innovative firms (business climate and incubators), scaling up strategies (venture capital), intellectual property (IP)/data strategies (including defensive instruments such as sovereign patent funds) and developing backward linkages to the front end of the innovation pipeline, namely pre-competitive science resources, through superclusters.
- Digital inclusiveness necessarily aims at digital literacy and internet access, with an emphasis on disadvantaged groups.

This is familiar territory from the business consultancy literature on corporate approaches to the digital transformation; from traditional innovation policy focused on clusters; and from the long-standing and well-articulated work toward an inclusive information society. Helpful as responses to these questions may be, the exercise is framed to validate existing policies developed in the era of the knowledge-based economy, rather than to develop innovation policies suitable for the data-driven economy.

With the digital transformation, economic activity, industrial processes, social and political interaction and public governance are rapidly shifting into the digital realm, where an astronomical number of events are captured, recorded and stored as data. Data must thus move to front and centre in policy considerations, and the characteristics of the data-driven economy must inform our understanding of innovation in this new economic age. Data and its governance, however, are only incidental to the framing of the issues above. This section takes up the implications of making data central to our thinking about industrial policy.

The Centrality of Data

Data plays several critical and very different roles in a data-driven economy: it is the medium for commercial transactions in digital space, the essential capital stock of the data-driven economy and the infrastructure of a digitized world.

- Data as intrinsic to commercial transactions: In this role, there is a need for free flow of data, including on a cross-border basis — this is the "fifth freedom" of commerce, alongside freedom to move labour, capital, goods and services. This is the role of data that is addressed in trade agreements such as the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP), which bans data localization and commits the parties to the free flow of data across borders (albeit with allowance for such restrictions as may be necessary to achieve a legitimate public policy objective).
- Data as an intangible capital asset: Big data is the essential capital stock of the data-driven economy through its role in training AI and, by extension, in enabling the creation of arbitrarily large amounts of machine knowledge capital as a complement to — and substitute for — human capital. This role of data is incompatible with "free movement" in the sense of "uncompensated movement," since that would be tantamount to "free" transfer of the most valuable assets of the digital age.
- Data as the infrastructure for a digitized economy: In this capacity, data must be safeguarded under strict, state-of-the-art terms. The e-Estonia model of blockchain-protected, localized data, backed up on servers in its embassies and with a complete backup in Luxembourg, was developed in response to a major episode of cyber attack on the fledgling digital economy (MacLellan and O'Leary 2017). It stands in apparent diametric opposition to the "cloud" model for business, which is envisaged in the CPTPP.

These three roles of data create different and seemingly inconsistent requirements for the policy architecture of the data-driven economy. This is a problematic trinity, and the approaches developed to deal with it will be the cornerstone of the industrial policy of this age.

Market Failure in the Data-driven Economy

The economics of the data-driven economy can be situated in familiar theoretical models of endogenous growth; at the same time, several structural features make this economy at least a special case of the general endogenous growth model, if not a new model altogether (Ciuriak 2018). A key issue is the prevalence of several characteristics that create market failure:

- Powerful economies of scale and scope and network externalities: The economies of scale in the data-driven economy are generated by the large up-front investments required to capture and store data. The economies of scope emerge because adding data points to a profile improves the power of the entire data set to predict and target by cross-referencing. The combination of massive economies of scale and scope together with powerful network externalities result in the emergence of superstar firms, which dominate their industries.
- Pervasive information asymmetries: AI creates an unbridgeable gap between human intelligence and AI, because big data cannot be processed by the human mind. By extension, there are similar information asymmetries between companies that command data resources and develop AI capability and those that do not. Indeed, the business model of the data-driven economy is based on exploitation of information asymmetry. By further extension, there are fundamental information asymmetries between countries that can build companies on data assets and those that cannot. Information asymmetry is, in some sense, the "original sin" of the data-driven economy.
- Replicator economics, asset-based incomes and concentration: Machine knowledge capital complements and competes with human capital just as robots complement and compete with unskilled labour. But where robots are expensive and take time to build and deploy, machine knowledge capital can be expanded at near zero

marginal cost and distributed globally with near frictionless ease. The digital world thus features "replicator economics" in the critical factor markets. The deployment of machine knowledge capital at massive scale promises to generate similar effects on returns to human capital in the advanced economies as the entry of China and India and the robotization of routine production had on blue-collar jobs and wages. By making robots more effective, it will also intensify the impacts of robotization on unskilled labour. The effects will be more pronounced and felt much more rapidly. Returns will flow to owners of machine knowledge capital, which will likely constitute the most valuable rent-generating assets of the data-driven economy, driving a steep increase in the concentration of wealth.

Each of these characteristics is a source of market failure in and of itself; the combination of the three creates a perfect storm of potential market failure — and with it, powerful inducements to industrial policy and strategic trade and investment policy. The latter effects are already very much in evidence in the frictions between the United States and China over China's ambition to achieve strategic advantage in AI and other advanced technology spheres by 2025. The digital trade wars have already begun (Ciuriak and Ptashkina 2018).

Associated Socio-political Issues

In addition to the core economic considerations raised by the above itemization of policy challenges posed by the data-driven economy, there will be a critical need for defences against the weaponization of information for social and political manipulation. These issues are not addressed here except peripherally where they crop up in delineating the sphere of industrial and strategic trade and investment policy. However, from the perspective of maintaining sustainable growth, these might well be the most important challenges that policy will have to address.

Guiding Principles for Industrial Policy in the Data-driven Economy

Addressing the Scaling Problem in the Data-driven Economy

Scaling up enterprises is vital to an economy's growth and job creation. For the data-driven economy, this challenge does not go away, but rather is compounded by an additional one: scaling up the data on which data-driven firms build their business. Accordingly, the scaling strategy has two parts.

Incentivizing Digitization, Aggregation and Mobilization of Data

Small economies generate fewer data than large economies; hence, there is a natural potential advantage for large population economies, such as China and India. In a similar vein, large companies that are able to capture data through proprietary means (those that provide online platforms or have large market shares in products that generate data) have a natural advantage over smaller rivals and would-be competitors. For small open economies, such as Canada, which lack these natural advantages, developing a strategy to access truly big data is thus the critical foundation of an overall data strategy.

Without pre-judging the nature of the data architecture that emerges to reconcile the problematic trinity conundrum concerning the multiple roles of data, small open economies can create an advantage by digitizing, aggregating and mobilizing data generated domestically and abroad. This problem is akin to that of incentivizing, aggregating and mobilizing savings to create financial capital.

One solution is analogous: data banks or data trusts. Taking the analogy forward, data banks would take "data deposits" from individuals and businesses, aggregate and anonymize them in line with privacy regulations, and make them available on commercial terms to firms building AI capabilities. Data depositors obtain returns on the data they deposit based on the earnings of the banks. This provides an incentive to digitize, even for firms that are uncertain as to how to use their own data. Data banks solve the aggregation problem, creating larger and more comprehensive data sets than would be possible for individual firms. By making the data commercially available for licensing fees to users best able to take advantage of the data resources, the banks mobilize the data.

A small open economy with a strong suit in governance, including regulation and supervision, and institutions that have capability in data storage, privacy protection and cyber security, is in a position to punch well above its population weight in developing the business of data banking. Indeed, by providing international access to its data banks for both depositors and users, a small open economy with these assets could grow to compete with the largest economies that follow strictly nationalist policies. Canada has these reputational assets and also an institutional base in the chartered banks that could evolve into the data banks conceptualized here.

Notably, this approach provides a private sector — albeit regulated — alternative to a purely state-managed data framework, introducing the benefits of competition and reducing vulnerability to disruptive shocks.

Another solution is to make data a public good: "a large part of the technology and necessary data was created by all of us, and should thus belong to all of us. The underlying infrastructure that…[the giant internet] companies rely on was created collectively (via the tax dollars that built the internet), and it also feeds off network effects that are produced collectively. There is indeed no reason why the public's data should not be owned by a public repository that sells the data to the tech giants, rather than vice versa" (Mazzucato 2018).

This suggestion (which echoes calls to regulate the internet platform companies like utilities) might be part of a general solution but it does not address the data generated in the Internet of Things (IoT), which promises to be the major area of data growth in the coming years.

Scaling Up Innovative Data-driven Firms

Industrial policies aimed at scaling firms kick in to support the growth of firms with promising data applications. High-growth enterprises typically constitute a small share of all firms in an economy, yet contribute in vast disproportion to growth and job creation (for the United Kingdom, see Anyadike-Danes et al. [2009] and Mason and Brown [2014]; for the United States, see Haltiwanger, Jarmin and Miranda [2010]). In Canada, high-growth firms constitute about six to seven percent of firms. A subset of these high-growth firms — the "gazelles"[6] — constitute about 0.5 percent of all firms in Canada. In Canada, as elsewhere, these firms account disproportionately for growth in output, jobs and exports. Innovation is key to their success (Mitusch and Schimke 2011; PwC 2013).

The scaling imperative for a country's innovation sector is well understood in research and policy circles and already figures prominently in modern industrial/innovation policies, including in practice: for example, Israel transformed itself into "the start-up economy" precisely because of state intervention through matching research grants and state venture capital funds (Senor and Singer 2009). Accordingly, given that Canada has a shortage of venture capital,[7] public sector capital needs to be added to the mix in substantial amounts to ensure Canadian gazelles remain in Canada and have access to capital to sustain their growth trajectory.

The Re-assignment of Investment Roles in the Data-driven Economy

Under modern conventions for market-oriented economies, the role of the public sector in the economy is directed toward creating a conducive environment for private sector activity; thus, "horizontal" economic infrastructure investment is encouraged but "vertical" or sector-specific interventions are discouraged, on the grounds that governments cannot "pick winners" and other similar aphorisms and arguments based on theories about public versus private sector governance, competence and incentives. However, investments do not come with horizontal or vertical stripes; this artificial construct was of questionable benefit in guiding policy historically, and it promises to be a stumbling block for sound policy going forward. A more useful framing of the issue is to look at potential investments in terms of risk-return metrics. Some investments

6 Gazelles are enterprises that are four to five years old with growth in revenue or employees over 20 percent per annum over a three-year period. Gazelles are required to have at least 10 employees at the start of the three-year period.

7 In a recent survey, venture capital in Canada was estimated as equivalent to only 0.031 percent of GDP, placing Canada fourteenth out of the 15 countries in the survey (Gillespie 2018).

have risk-return metrics that will be attractive to the private sector and some will not. The reasons for private investors not committing include:

- the benefits might not be sufficiently appropriable by the investor;
- the returns might not be realizable in a short enough time span; or
- the project might be too speculative or the risks might be too great (including due to the scale of the project) or not sufficiently quantifiable for private sector engagement.

Notably, the fact that investments do not meet the requirements of private investors does not mean they lack value to society. For example:

- the weaker the appropriability, the larger the positive spillovers for the economy and the stronger the grounds for public investment;
- society has a lower rate of discount for future returns[8] and, thus, can take a longer time frame to realize returns than private investors; and
- private capital is, by nature, risk averse and, in a world of virtually unfettered capital mobility, has the luxury of sitting out uncertainty in tax havens (when private capital bails out, the public sector must bail in, as has been repeatedly shown in periods of crisis).

Accordingly, the mere fact that the private sector might take a pass on an investment does not mean that the public sector should as well. In the data-driven economy, the risk-return calculus sorting investments into the private and public spheres shifts on all three grounds.

Appropriability and the Vertical/Horizontal Industrial Policy Filter

It is convenient to unpack the issue of appropriability by referencing a taxonomy developed by Donald E. Stokes (1997), which parses out research into pure science with no immediate application in mind; pure applied science, which is entirely focused on immediate applications; and a third category, inspired by the work of Louis Pasteur and hence labelled "Pasteur's Quadrant," which delves into fundamental scientific questions and has immediate applications of value for society.

An important example of a research and development (R&D) program that operates in this latter space is the US Defense Advanced Research Program Agency (DARPA) program, which funds a wide range of often "blue sky" projects with uncertain prospects and unclear commercial potential. Matt Hourihan and Matthew Stepp (2011, 3) describe the DARPA approach as follows: "DARPA operates in what is known as "Pasteur's Quadrant," where fundamental science crosses paths with goal-oriented applied research. This approach has yielded significant technological leaps forward in fields like information technology and the global positioning system (GPS) — but just as importantly, it has produced a model that demonstrates how government can successfully and quickly support the development of experimental technologies that can change the world economy."[9]

DARPA is widely considered in innovation circles to be the backbone of US innovation success because of the knowledge spillovers it generates for the private sector participants.[10] Projects under this program can be classified into both vertical and horizontal categories, underscoring the disutility of using this taxonomy to identify what is suitable for public sector engagement and what is not. Similarly, such projects do not neatly fit the classification under which the public sector is assigned the role of funding basic exploratory science while the private sector is left to identify how this is best deployed for commercial ends.[11]

In the data-driven economy, in which the application of data generated by the IoT will have transformative impacts on industrial sectors, the public sector will need to be prepared to engage

8 A recent review of the rate of social time preference for the United Kingdom's Treasury Department adopted a 3.5 percent return as being in the middle of current estimates (Freeman, Groom and Spackman 2018).

9 See also Regina E. Dugan and Kaigham J. Gabriel (2013, 1), who write that "the agency's advances have played a central role in creating a host of multibillion-dollar industries."

10 For example, William Bonvillian's (2009) argument for a "connected" technology system for the United States. For a Canadian perspective, see Conor Smith (2014).

11 This long-standing taxonomy dates from Vannevar Bush's (1945) report to President Franklin Delano Roosevelt on the role of government in funding science (see Bonvillian 2009). This heavily influenced US policy in adopting the "pipeline" approach, in which public funding supports research that goes in one end of the pipeline and commercial technology emerges from the other end, as well as other countries' policies that followed suit.

in areas where appropriability is an issue, without regard for the vertical/horizontal taxonomy.

For trade policy, this has further important consequences, since trade remedies are allowed to counter "specific" subsidies on grounds that these are trade distorting; in the data-driven economy, there can be no presumption that public investments that can be categorized as "specific subsidies" are trade distorting. WTO rules will need to be revised to adapt.

Acceleration of Change and Implications for Public Sector Investment

Acceleration of the pace of change in the data-driven economy affects the assignment of projects to the public and private spheres by reducing the time frame that must be allowed for investments to be recouped with any measurable probability. In turn, this necessarily shrinks the pool of viable investments for the private sector.

Internalizing this point, we can see that the data-driven economy will feature investment behaviour of private capital that is different than historically. By the same token, public sector investment — which is integral to industrial policy — will also have to play a greater role to ensure that socially optimal investments are not left sitting on the table. Notably, these investments will not fall neatly into the "horizontal" category ordained by conventional policy guidelines — indeed, they will be investments that would be naturally assigned to the private sector under current orthodoxy.

Risk Aversion

The understanding that private capital is averse to risk at a critical stage of the innovation process is a fundamental part of the rationale for the US Small Business Innovation Research (SBIR) program:

> SBIR was created to...provide funding for some of the best early-stage innovation ideas — ideas that, however promising, are still too high-risk for private investors, including venture capital firms....In 2005 only 18 percent of all U.S. venture capital invested went to seed and early stage firms while 82 percent went to later stages of development that are lower risk.
>
> SBIR addresses a paradox at the heart of innovation funding: capital is always short until the test results are in. At the idea stage, and even the early development stage, the risks are too great for all but a few investors. But innovations can't get beyond that stage without funding. (Tibbets 2008, 1-2)

In the data-driven economy, this rationale for public innovation funding gains greater force since the transformative nature of technological change heightens the risk of all potential investments.

At the same time, the appetite for risk in the private sector will be skewed by concentration of wealth. Past a certain number of billions of dollars, the very wealthy inevitably lose sensitivity to risk and can underwrite projects that private enterprises normally could not contemplate without sovereign guarantee. Thus, we see private capital generally hesitant to commit to investments, while, at the same time, Elon Musk's SpaceX sends a sports car into space.

FDI

The traditional motives to pursue inward FDI in many industrial and services sectors include the boost to capital formation, the capture of global mandates for export production by the multinational firm ("platform" FDI), the inflow of leading-edge technology and know-how and the competitive pressure the foreign firm would bring to the domestic economy.

However, in the knowledge-based and data-driven economy, FDI comes mainly through M&A and targets knowledge assets — patent portfolios, promising start-ups or knowledge benefits from participating in research-intensive hubs (for example, the establishment of a research laboratory in Canada by a firm like Google or Huawei, to pick a more controversial investor, to conduct AI research). The motives for inward FDI in this context change the net benefit calculus for host countries.

On the positive side, if the activity remains in the host country, the connection with a multinational firm can provide benefits such as removing capital constraints on growth, providing global markets for the host country's products and generating employment for host country researchers who might otherwise leave for labs abroad. As well, the ability to sell a start-up to the highest bidder is part of the incentive framework for entrepreneurs and, indeed, the business model for serial entrepreneurs.

On the negative side, the acquisition can dampen the dynamism of the host economy in several ways.

First, its motive might be to block the emergence of a future competitor — as Steven Davidoff Solomon (2016) observes: "Facebook and its elite brethren will do anything to make sure they are not the next Yahoo or Radio Shack, killed by disruption and failure to innovate. This translates into paying obscene sums for technology that might challenge their dominance one day." This type of anti-competitive strategy is not new and has other manifestations as well — for example, firms patenting to throw roadblocks in the way of competitors rather than for commercial exploitation.

Second, the foreign investors might relocate the knowledge-generating activities to their own headquarters abroad, since R&D tends to be done disproportionately at the headquarters of multinational firms (National Science Board 2010).

Third, even when the activity remains in the host country, the flow of knowledge assets is outward, including patents generated by researchers in the host country and data generated by projects. This latter feature has become a prominent concern in US policy regarding Chinese investment in its knowledge-based sectors due to geopolitical rivalry; however, it is also relevant from a host country perspective regardless of the nationality of the investor (for example, Google's Sidewalk project in Toronto) given the role of knowledge assets in generating wealth.

The dynamic concerns raised by these points should be pre-eminent for host economies at a time when the data-driven economy is taking shape. The first two considerations are developed below; the third point is addressed in the following section discussing policy for an asset-based economy.

Anti-competitive Acquisitions

Since FIRA days, the government has rarely intervened in proposed takeovers of Canadian firms. When it has intervened, it has been for national security reasons (for example, MacDonald Dettwiler) or the takeover of what was considered a "strategic asset" (for example, Potash Corporation). The high threshold of review of takeovers under Canada's trade agreements (currently CDN$1 billion in Canadian assets for WTO members and CDN$1.5 billion for Canada's free trade partners) means that acquisition of upstart competitors by multinational firms will largely pass without policy scrutiny. Yet it is these upstart competitors that might be the most strategic assets in the innovation age, in particular during the formative years of the data-driven economy.

A large economy with a vibrant innovation sector like the United States can be largely indifferent to preventative takeover strategies because the majority of the cases are US firms taking over US firms (the United States does, however, tend to be circumspect about allowing investment in technology assets when it comes from geopolitical rivals). Canada cannot afford such indifference, given that such takeovers can materially reduce innovation dynamism in Canada's much smaller technology sector. High-growth firms, especially gazelles, are the most likely acquisition targets by multinationals.

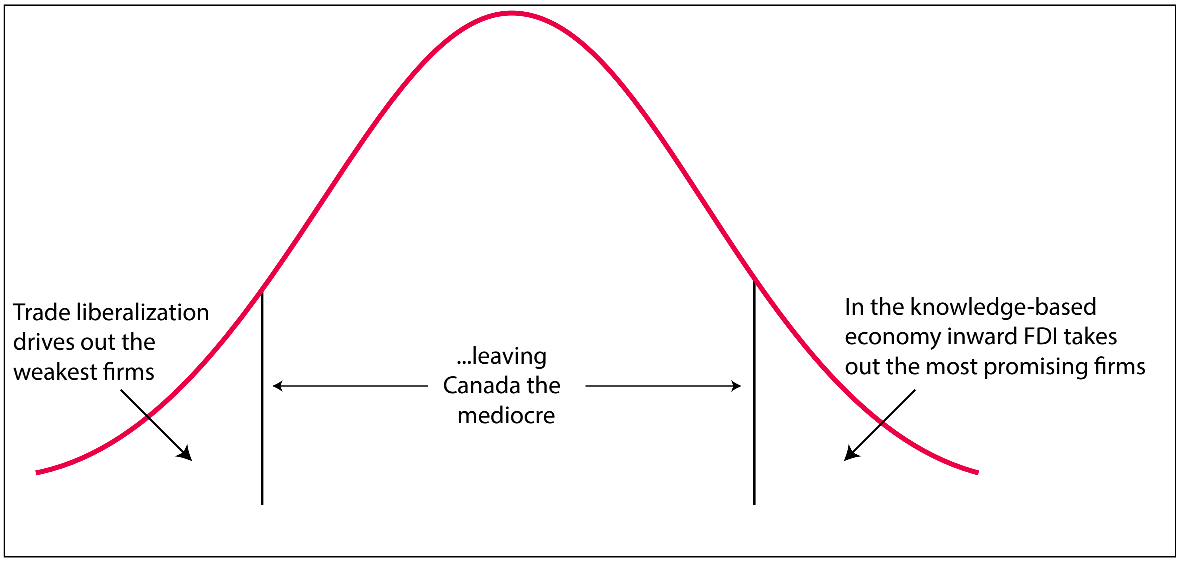
Impact on Dynamism of Clusters

The existence of clusters indicates that local knowledge spillovers are important. Specific elements that underpin successful clusters include: a critical mass of dynamic, innovative firms; the availability of the usual factors of production (capital, labour, intermediate inputs and business services); an operational context that includes a supportive policy and a well-developed institutional framework and economic infrastructure; and easy access to domestic and foreign markets. While there are many variations on this theme, the essential point that emerges from the cluster literature is that the successful firm sits in a rich context, connected to factor and product markets, suppliers and customers, collaborators and competitors (Curtis and Ciuriak 2010).

Enriching an innovation system with a diversity of firms and researchers is vital to its performance. New technologies emerge by combining existing ideas or technologies.[12] Combinatorial growth dominates exponential growth the way that exponential growth dominates linear growth. Accordingly, the innovation potential of a region

12 As pointed out long ago by Henri Poincaré (1908), new ideas emerge from combining existing ideas. Alexander Graham Bell is a classic Canadian example. He was professionally involved with hearing problems and teaching the deaf. His avocation was electronics. He combined his knowledge of the ear with his electronic hobby to generate the telephone. See www.thecanadianencyclopedia.ca/en/article/alexander-graham-bell/. Martin L. Weitzman (1998) comments on the recombinant nature of innovation.

Figure 2: Trade Liberalization vs. Inward FDI Impact on the Population of Firms



Source: Author.

or cluster through recombination is powerfully augmented by the acquisition of additional knowledge assets — which includes new technology start-ups, technology acquired by outward technology-seeking FDI, relocation of firms' R&D activity into the cluster (typically to gain access to the turnover of skilled workers) and the immigration of highly skilled persons. By the same token, the loss of technology firms or skilled workers to other countries, including through M&A-type inward FDI, which results in a relocation of R&D activity to the acquiring firm's home base, and the poaching of top talent, saps the innovation potential of a cluster.

Focusing on the impact of inward FDI on the population of firms, several observations can be made. First, trade liberalization eliminates the weakest tail of the population of firms, improving the economy's overall productivity. Second, FDI in the form of greenfield investment in the traditional industrial economy expands the economy's right tail of highly productive firms, similarly improving the overall productivity of the economy. However, in the knowledge-based economy, FDI of the M&A type tends to target the most promising, fastest-growing firms with the potential to become gazelles. If the dominant effect of such FDI is to repatriate the R&D activities abroad, such FDI would reduce the host economy's stock of knowledge capital and leave it with the "mediocre middle."

This creates the need for a new public policy filter for screening inward FDI to determine whether there is a net benefit, with the principal criterion of reviewability being the implication for the dynamism of Canada's innovation system. Such a review can be justified on conventional economic grounds based on externalities: public intervention would be warranted where the appropriable private returns to an individual start-up from selling to a foreign firm do not reflect the externalities that the start-up firm's presence in a given innovation location generates for the location — in other words, where there is a public interest in the transaction that goes beyond the private interest.

Industrial Policy for an Asset-based Economy

As advanced industrial economies evolved into knowledge-based economies, and now are increasingly evolving into data-based economies, intangible assets (including protected IP and proprietary data) have become an increasingly important source of wealth, and profits (rents) have increased their share of income. The Standard & Poor's 500 is already dominated by data-driven firms; the five largest accounted for about US$4 trillion in asset values in mid-2018 (Batnick 2018). As machine knowledge capital grows in importance, the share of income captured by rents will grow. Prosperity at the national level will be increasingly tied to ownership of rent-generating assets.

The rent-based business model of the data-driven economy thus makes asset accumulation essential for national wealth creation. By the same token, policy focus must shift from activity (GDP) to income (gross national income) and economic strategy must shift from a primary focus on activity and jobs to building a rent-generating stock of technology assets. This would be a departure for Canada, which did not treat IP stocks as a strategic economic asset in responding to the technology bust. For example, the government did not intervene in the sale of Nortel's CDN$4.5 billion patent portfolio, nor did it create a state patent fund to defend the value of the domestic IP assets.

A focus on building an asset portfolio points to a number of specific policies that would help achieve that goal:

→ a retention policy for domestically developed knowledge capital created with public funding support;

→ a state patent fund to ensure freedom to operate for Canadian technology firms, in particular in the AI/machine learning space, where an IP arms race is under way, given that IP can be weaponized for exclusion strategies; and

→ support for Canadian investment abroad in technology-intensive sectors to generate knowledge capital acquisition and knowledge spillovers back to Canada.

Canada's existing international commitments do not provide for review of M&A investment in technology-intensive sectors based on innovation spillovers, irrespective of the size of the target. Accordingly, any conditionality to be applied going forward would depend on contractual terms for domestic funding assistance.

International Agreements

Canada's footprint in the future global data-driven economy will be commensurate with its share of global data capital and related IP — and this share will depend heavily on the extent to which Canadian data is captured by Canadian firms in areas where first-mover advantage has not yet been firmly established. Canada's technology sector is contributing to disruptive technologies in areas such as AI and machine learning. This points to a niche data strategy focused on the IoT as opposed to the internet itself. As to which sectors would be most significant for Canada, there is no need to "pick winners" per se — the data should dictate where Canada has comparative advantage. Likely sectors are geophysical (energy, mining and agriculture), smart cities and health (Medhora et al. 2018). From an analytical perspective, the challenge would be to identify the data assets that could be assembled. This, in turn, would inform policy approaches.

Canada needs to retain flexibility under its future trade agreements to implement such a data strategy. This goes well beyond the notion of the "right to regulate" in respect of privacy, national security and preservation of democratic processes, which addresses negative externalities of the use of data. The recognition that data has vast commercial value is key, just as is the case with — and indeed much more so than — market access in the handful of remaining protected areas in international trade in goods and services.

Government procurement remains one of the areas where flexibility has been retained. This flexibility should be used — for example, by tailoring procurement contracts to ensure that data capture is included and that the data would be acquired by the public agencies tendering the contracts.

Given the extreme heterogeneity of data and the wide range of regulatory issues that have already been encountered (for example, privacy, election financing/advertising, competition, security and so on), an undifferentiated regime for the cross-border flow of data is untenable. The European Union has taken the lead in setting standards for the protection of personal data with its General Data Protection Regulation; however, as argued above, the personal/non-personal distinction does not get at the issue of the multiple roles that data plays in the modern economy, each of which appears to require different approaches to cross-border flows. Given the limited experience base with the dynamics of the data-driven economy, presumptions as to what regulatory restrictions will ultimately be required are premature. Trade agreements should preserve regulatory flexibility, including by introducing references to the multiple roles of data, the risks of market failure in the data-driven economy, the need to preserve competitive access to data and associated competition policy disciplines on abuse of the control of data acquired due to control of networks.

Conclusions

The digital transformation is creating economic conditions that are fundamentally different than those that prevailed during the two centuries that witnessed the industrial revolution, and the three decades or so that witnessed the transformation of advanced economies into knowledge-based economies. With this transformation, the accepted norms for advanced economies regarding the respective roles of the private and public sectors in economic activity are changing. Accordingly, industrial and innovation policy have to be reconsidered in terms of how, why and where they are to be applied, based on the centrality of data to the data-driven digital economy, the various roles that data plays in this economy (as medium of digital transactions, as intangible capital and as infrastructure of a digitized economy) and the heightened scope for market failure in this economy.

Scaling up remains a fundamental challenge, but the critical issue for the small open economy is now scaling up the data to which an economy's firms have access. Just as data is foundational for the data-driven economy, ensuring access to data — the bigger the better — is foundational for industrial and innovation policy in this era.

The acceleration of the pace of change in the data-driven economy changes the set of investments with risk-return metrics that the private sector will engage. In particular, it shortens the time horizon for recouping investments. At the same time, the skewing of income and wealth affects the process that decides which investments to make. Public policy must support projects that have social merit but which private capital leaves on the table, and which would be screened out by conventional criteria for industrial policy interventions by the public sector.

The impact of FDI depends on the context. In the knowledge-based and data-driven economy, policy must consider the impact of inward M&A investment on the dynamism of Canada's innovation system, in particular where such takeovers would have anti-competitive effects or materially reduce knowledge spillover benefits within Canada's innovation system.

Income and wealth are increasingly asset based. In a rentier economy, prosperity is based on ownership of rent-generating assets. Industrial policy — and indeed economic policy more generally — must be attuned to whether policies result in the accumulation of assets or their depletion. Policy must therefore shift from focusing on activity to building a rent-generating stock of technology assets, including by adopting a retention policy for domestically developed knowledge capital produced with public funding support; giving appropriate weight to the implications for Canada's stock of technology assets of FDI, including the potential loss of technology through inward M&A-type FDI and potential gain of technology through outward FDI; and ensuring freedom to operate for Canadian technology firms through, for example, a state patent fund to address issues related to patent proliferation.

Finally, Canada's international commitments need to preserve policy space to implement a data strategy to secure a foothold for Canada in this emerging economy. As part of its data strategy, Canada should assess the market value of data generated in the exercise of public sector governance and data captured in Canadian public space (Wylie 2018); put in place procedures to capture data and regulate its capture; and use procurement to develop new capabilities in Canada's private sector.

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