Economic Doctrine Is in Flux: What are the Implications for Canada's Regional and Multilateral Trade Engagement?

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Abstract: The current opportunities for Canada's reengagement with the United States present themselves at a moment of profound changes in economic thinking in the United States and beyond. There are many factors behind the renewed interest in industrial policy, including the experience of the COVID-19 pandemic, the geopolitical competition with China, the return of shortages and inflationary pressures, the concerns about anti-competitive behaviour of platform firms, and the distributional dynamics of the data-driven economy. These have broad implications for trade policy and for the strategic approach for small, open economies like Canada. In an innovation-intensive world of superstar firms and geostrategic competition, the focus for Canada should be on innovation and firms. The measure of success: Canada's count of unicorns would be rising steeply, as would be Canada's R&D share of GDP, and private and public venture capital support for Canadian technology-intensive companies would be breaking records. Canada's economic history is punctuated by the establishment of Crown Corporations to fill gaps. The maturation of the industrial era economy may have given the impression that this was history. Today, it's not a question of necessarily resorted to Crown Corporations, but Canada should not hesitate to go that route if necessary.

Keywords: Canada-US relations, industrial policy, geopolitics, geoeconomics, data-driven economy, digital transformation, trade policy

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1 Introduction

The incumbent global trade policy framework based on the World Trade Organization (WTO) Agreement and a complementary set of preferential trade agreements (PTAs) of varying depth and comprehensiveness, with established interfaces with non-trade issues such as the environment, social choices in areas ranging from health to social mores, and national security, has been shaken by a confluence of secular trends and changing technological conditions. The list is well-known:

- The digital transformation and the emergence of a data-driven economy that features a new form of productive capital – data – which generates large economic rents (Ciuriak, 2018) and whose pervasive, protean and permanent characteristics create fundamental new social and political conditions that will necessarily elicit social and political responses (Ciuriak and Wylie, 2018).
- The emergence of new general-purpose technologies based on big data, machine learning and artificial intelligence which are key to economic prosperity and military applications.
- The acceleration in the pace of innovation, which comes with both steeply rising resource costs for cutting edge (or bleeding edge) innovation, and cloud computing business models – "platform as a service" (PaaS), "software as a service" (SaaS) and "infrastructure as a service" (IaaS) – that provide small firms affordable access to computing power and technology that would otherwise be prohibitively expensive (Byrne et al., 2018).
- The rise of China as a geopolitical competitor to the United States, which ended the transient unipolar moment that followed the demise of the Soviet Union.
- The cumulative effect of growing human pressure on the climate and biosphere, which is generating new societal challenges by invalidating the built infrastructure and threatening the ecosystem support for human subsistence from fisheries to forests to fauna (in the latter case from bees to belugas).
- The economic shock generated by the Covid-19 pandemic, which highlighted vulnerabilities of economic interdependence and risks in extended supply chains, including the disruptions to the container-based logistics systems, which has been described as "containergeddon" (Baertlein et al., 2021).
- The adaptation of business models to the modern technological environment, which has been accelerated by the pandemic through solutions such as remote work and teleconferencing and vastly expanded virtual shopping. Many more changes are looming on the horizon including increased deployment of autonomous vehicles and drones, increasingly flexible robots, and AI applications that constitute "machine knowledge capital" that will both complement and replace human capital in production (Ciuriak, 2018).

In response, governments have thrown previously unheard of sums of money at problems, tossed out the rulebook on industrial policies, and engaged in strategic trade and investment competition that has smashed through the guardrails established by the WTO, often in the name of national security. The latter concept that has been expanded to include everything from food and energy security to technological competitiveness, to cybersecurity, and even cultural property (see Heath, 2021, on the securitization of issues).

For its part, the business sector is scrambling to reposition itself for the new operating environment and is seeing a rapid evolution of the ecosystem of innovative firms: 2021 has seen a record number of start-ups reaching the status of "unicorn" – a $1 billion valuation for a private start-up: CEO Today reported recently that 250 companies attained unicorn status in the first seven months of 2021, compared to 161 for the whole of 2020 (Hristova, 2021). The parallel to the post-Spanish Flu boom in start-ups has been noted (The Economist, 2021)

And households appear to be taking advantage of the economic shock – alternatively have been driven by the economic shock – to change where they live, where they work, and indeed how much they work. This is the so-called "great resignation" (Tharoor, 2021) – or alternatively a protest against unsafe and precarious working conditions. Just as was the case following the Black Death in Europe (which is cited as one of the possible triggers for the labour-saving innovation that led to the industrial revolution; Allen, 2009), and following the Spanish Flu pandemic, which at least temporarily strengthened the bargaining power of labour (Mintzer, 2020), the pandemic appears to have induced a structural shift in factor markets (Hawthorn, 2021).

For the trade policy community, the world is thus moving under our feet. As has been the norm for much of recent history, the impacts and responses are more pronounced in the United States than in Canada. And, as has been the norm in much of recent history, US responses have a disproportionately large impact on Canada, notwithstanding that Canada is not the source of the shocks or the principal target of US policies. Accordingly, it is important to both understand the dynamics that are reshaping our world and to anticipate how they will impact on our largest trading partner as well as on the broader multilateral trading system in order to prepare Canada to optimize its own policy responses.

In this note, I focus on the role of technological conditions in shaping the economic conditions on which the established trade policy framework is premised and how the changing technological conditions tend to invalidate this framework. I then draw conclusions (as preliminary as these may be) for the prospects of a rules-based system going forward – and how Canada might navigate this treacherous environment.

2 Technological Conditions and the Rules-Based System - Some History

The governance regime established by the General Agreement on Tariffs and Trade (GATT) and embellished through eight rounds of multilateral negotiations, culminating in the WTO Agreement, was in hindsight ideally and perhaps uniquely suited to the mature industrial economy of the postwar era, in which and for which it was tailored.

In particular, this economy featured as stylized facts constant returns to scale and stability of the shares of national income flowing to capital and labour (see Kaldor, 1961). These conditions imply competitive market conditions and by extension only a limited presence of economic rents.

Under competitive market conditions, markets allocate production and market share efficiently and indeed fairly. Under the principle of comparative advantage, all nations find their niche and share in the benefits through trade. In the absence of rents, it is convenient for nations to allow commercial disputes to be settled by legal principles.

Around 1980, things started to change, not because of Margaret Thatcher and Ronald Reagan as often supposed, but because technological conditions were changing with profound implications for the trade system. There were a number of markers.

First, notice that something was in the air is provided by a series of papers that introduced "new trade theory",[1] which is based on firms facing increasing returns, product differentiation and imperfect competition. These conditions imply the existence of economic rents. Shortly thereafter Brander and Spencer (1983, 1985) set out how strategic trade behaviour can be motivated by these conditions and the contest by nations to capture the rents. The term "strategic trade policy" was coined to describe the behaviour (Krugman, 1994).

These new theories built on the business literature on multinational enterprises (MNEs) that had developed in the 1970s.[2] MNEs gained the attention of analysts in that decade's new operating environment of liberalizing capital accounts, regulatory changes that facilitated inter-modal logistics, and the introduction of the wide-body Boeing 747 with a design based on capability for cargo transport. These developments established the basis for a shift from vertically integrated national firms to global value chains (GVCs).

International supply chains were sufficiently developed by the early 1980s to give rise to the term "supply chain management" (SCM), which appears to have first been used in print in 1982.[3] This can be considered a second marker. By the mid-1980s, when the first mention of GVCs was made in the literature, Grunwald and Flam (1985) published the monograph "The Global Factory."

A third and perhaps the most important marker was the passage by the Carter Administration of the Bayh-Dole Act in December of 1980 to encourage commercialization of university-conducted research. This underscores recognition in US policy circles of the growing importance of intellectual property (IP) for the US economy. Policy recognition is one thing; technological capabilities to deliver is another. The key enabling technological development to build on Bayh-Dole came hard on the heels of this legislation with the introduction of the IBM personal computer in 1981, which enabled the widespread adoption across industries of computer-aided design and manufacturing (CAD/CAM). This effectively industrialized research and development (R&D), accelerating the pace of innovation. The visible indicator of this acceleration was in patenting activity, which started to turn up around 1980 and then steepened sharply.

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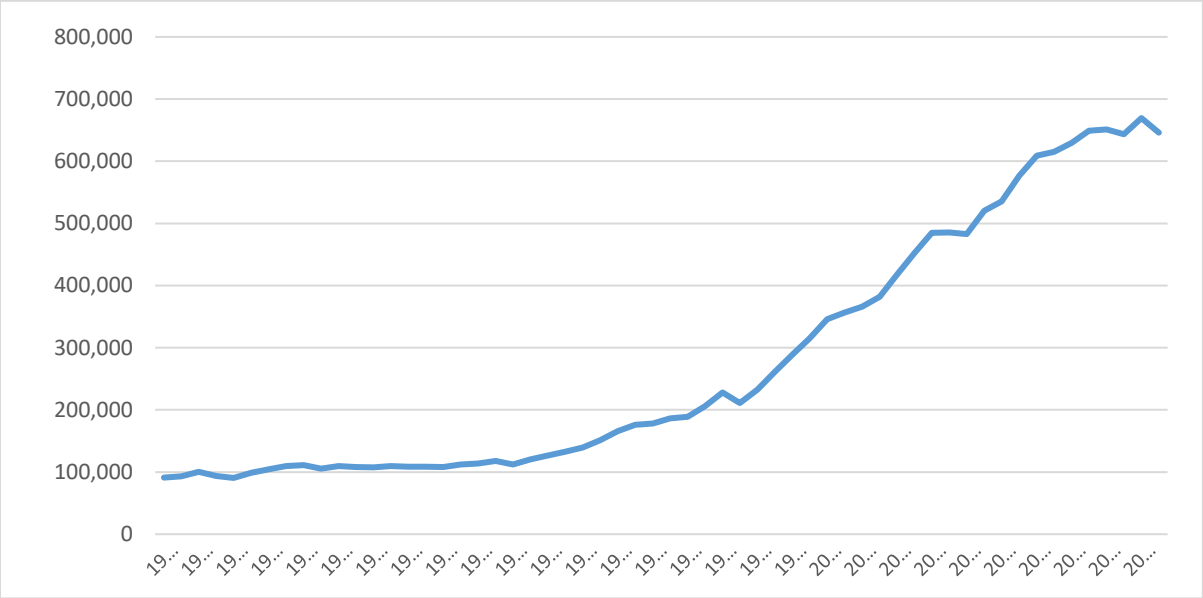
[1] The standard references are Krugman (1979, 1980 and 1981); Dixit and Norman (1980); Lancaster (1980); Helpman (1981): and Ethier (1982).

[2] Major contributors to this literature include Hymer (1960/1976; Caves (1971); Buckley and Casson (1976); and Dunning (1977).

[3] The term appears to have been first used by the consulting firm Booz Allen & Hamilton and appeared in the German journal Wirtschaftswoche in 1982, before being picked in the English language media and the trade literature (Ciuriak, 2016).

Figure 1: US Total Patent Applications, 1963-2020



Source: US Patent and Trademark Office (USPTO). https://www.uspto.gov/web/offices/ac/ido/oeip/taf/us_stat.htm

The rise in the share of intangibles in corporate assets was underway. At the same time, the labour share of income started to trend down and the profit share to trend up.

It is also notable that US income distribution dynamics also changed around 1980. As Krugman (2014) observes, US data from the Census Bureau's annual survey and the Federal Reserve's triennial survey show that "Before [1980], families at all levels saw their incomes grow more or less in tandem with the growth of the economy as a whole. After 1980, however, the lion's share of gains went to the top end of the income distribution, with families in the bottom half lagging far behind." The timing of this trend is important to bear in mind when considering arguments about the role of China's accession to the WTO in US income distribution.

There was a phase change in the behaviour of the economy circa 1980 and it is reasonable to date the transition to a knowledge-based economy (KBE) accordingly. This had profound implications for trade policy.

First, the shift in rent capture from manufacturing and traditional services to IP meant that these sectors were now petitioners for protection to regenerate rents as US comparative advantage shifted towards knowledge-based assets while comparative advantage in manufacturing and basic services shifted increasingly to the emerging markets in Asia. Notably, the era of trade remedies for traditional industries starts in 1979. This has an institutional dimension since it follows the consolidation of trade remedy determinations of dumping and injury in the Department of Commerce and the International Trade Commission within that department. Previously, Treasury had been responsible for determination of whether sales were at less than fair values; while Treasury rarely found less-than-fair-value sales, Commerce rarely failed to find them (Irwin, 2005). The timing is more than suggestive since the 1980s also witnessed the rise of "grey area measures" (voluntary export restraints or VERs and so forth) all of which worked with AD/CVD measures to generate rents for protected sectors (Ciuriak et al., 2013).

Meanwhile the rising share of economic rent in the system triggered a contest to capture them. The competition for rents is settled by bargaining power and other forms of market power under conditions of strategic behaviour, and the result (at the margin) is not win-win, but rather a transfer of wealth. And it is not a contest that nations will readily cede to independent tribunals, at least not when the stakes are large. The subsidy and trade protection wars over dynamic random access memory (DRAM) chips and civilian aircraft (Boeing vs. Airbus; later Bombardier vs. Embraer) were a taste of what was to come. What did we see in this era? The active use of instruments such as Super 301 to leverage concessions from trading partners (e.g., the Structural Impediments Initiative commitments made by Japan; Matsushita, 1990). The Uruguay Round was in good part about trying to put the use of these instruments back under wraps.

If we date the KBE/GVC world to 1980, the world for which the WTO was created in 1995 was one whose life was already half over. Indeed, by 1995, foreshadowing what was to come, the World-Wide Web was already five years old although not yet commercially a force; and in 1996, the first known use of the term "cloud computing" would be made in a Compaq internal analysis (Regalado, 2011). Which brings us to the technological conditions of the DDE.

3 The Technological Conditions of the Data-Driven Economy

3.1 Arrival

As we fast-forward 15 years from the foundation of the WTO to 2010, the world is emerging from the Great Financial Crisis (GFC). But the truly momentous developments of the late 2000s were not the transient GFC but rather three technological innovations that would shape the world that emerged from the GFC:

- the development in 2006 of deep learning techniques based on stacked neural nets by Geoffrey Hinton at the University of Toronto (Kelly, 2014);
- the introduction by Apple of the iPhone in 2007 which launched the age of mobile and sent soaring the amount of data continuously accumulated and streamed into the now rapidly expanding cloud (Molla, 2017); and
- the application by Andrew Ng and his team at Stanford in 2009 of graphics processing units (GPUs) – computer chips designed for the massively parallel processing requirements of videogames – to run stacked neural nets (Kelly, 2014).

At a presentation at the Barcelona World Mobile Conference in 2010, Google's Eric Schmidt announced the arrival of a new age. Schmidt described it as the age of mobile – mobile computing and mobile data networks. He goes on to say that:

> "…these networks are now so pervasive, we can literally know everything if we want to. What people are doing, what people care about, information that's monitored, we can literally know it, if we want to and if people want us to know it." [4]

[4] https://www.youtube.com/watch?v=ClkQA2Lb_iE

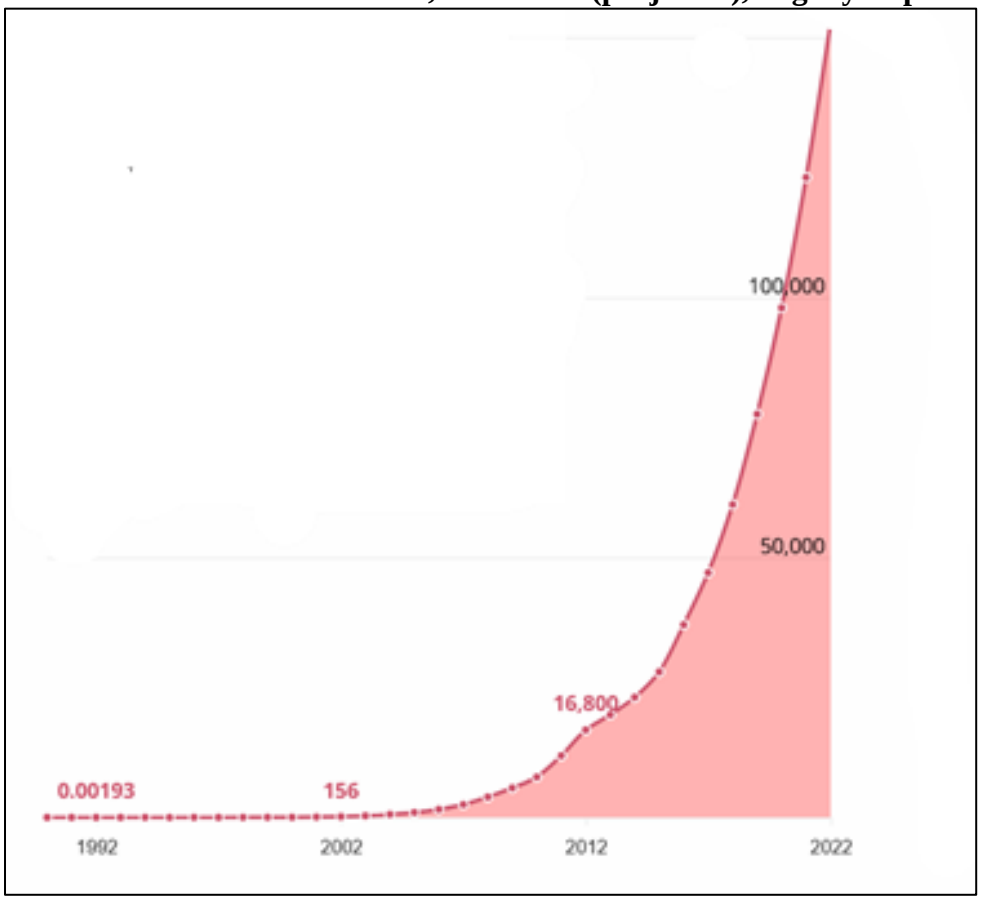
It is more than eye-opening in light of this to consider a story told by Kevin Kelly, the former editor of Wired, of a conversation some years earlier with Larry Page, the co-founder and future CEO of Google, about Google's free web service:

> "Around 2002 I attended a small party for Google—before its IPO, when it only focused on search. I struck up a conversation with Larry Page, Google's brilliant cofounder, who became the company's CEO in 2011. "Larry, I still don't get it. There are so many search companies. Web search, for free? Where does that get you?" … Page's reply has always stuck with me: 'Oh, we're really making an AI.' " (Kelly, 2014)

The world for which Google was built had arrived. It was the world of big data, machine learning and artificial intelligence – the data-driven economy (DDE).

As can be seen from Figure 2, the major part in the growth of the volume of Internet traffic – and hence the scale of datafication – came after the world emerged from the GFC.

Figure 2: Growth in Internet Traffic, 1992-2022 (projected), Gigabytes per second



Source: World Bank (2021). World Development Report 2021 and Cisco Visual Networking Index: Forecast and Trends, 2017–2022; https://wdr2021.worldbank.org/stories/crossing-borders/

It seems reasonable to date this second phase change to circa 2010. The term "data-driven economy" starts to show up in the economic literature as early as 2011 in an OECD work program (see note 1 in Ciuriak, 2017a) but, with few exceptions, the main body of literature on this subject

is in the second half of the 2000-teens when this became a widely used term of art. Notably, Abe's 2019 Davos speech emphasizes the role of data as *driving* the economy:

> "…for decades to come, it will be **digital data driving our economy forward**. We had better act now, because coming into being every single day is more than 2.5 quintillion bytes of data, which is, according to one estimate, as much as two hundred fifty thousand times the printed material in the U.S. Library of Congress. A delay of one year means we will be light years behind." (Abe, 2019; emphasis added)

The title of Abe's speech was about a "hope-driven economy"; but the "hope" is really data.

3.2 Market Failure

The DDE is qualitatively different from the preceding industrial and knowledge-based economies. It behaves differently and is particularly prone to market failure because of certain features:

- Steep economies of scale, which emerge from the investment costs to capture, classify and curate data (see, e.g., Google's massive server farms) and to successfully monetize it.
- Powerful economies of scope due to the increase in the value of data the more it can be cross-referenced through relational databases.
- Network externalities in many use cases, including two-sided markets that are prone to "tipping" in favour of one firm, which then dominates both markets.
- Irreducible information asymmetry, which can be thought of as an industrial strength "sixth sense" with all the evolutionary advantages that this implies for those companies that possess it – this is the "original sin" of the DDE in the sense that exploiting a market failure is the very basis of the business model of this economy.

These features (elaborated in Ciuriak, 2018) combine to drive the emergence of superstar firms (Autor et al., 2020). Given the scalability of the digital economy, these superstar firms are superstars at a global level The ability to achieve market concentration at a global level is best exemplified by the fact that Facebook can boast of having more users than the populations of the United States, the European Union and China combined. Firms that succeed in figuring out how to use data to improve their products or production processes can gain a powerful competitive edge (e.g., McKinsey Analytics, 2020; Ciuriak and Rodionova, 2021). Note that "winner-take-most" outcomes are not implied for all firms; this depends on whether the data advantage translates into network effects (Hagiu and Wright, 2020). However, data advantages drive outsized returns.

The original theoretical article on the economics of superstars, which demonstrated how superstars capture outsized market share and economic rents, was written by Sherwin Rosen at the dawn of the knowledge-based era in 1981, when the economy was still tangibles-intensive. It was ahead of its time by an economic age.

3.3 Scalability in Services and the Baumol Effect

Here it is salient to mention an aspect of the economics of data that has drawn little attention. The DDE emerged in a services-intensive economy that is subject to the "Baumol effect" (Baumol,

1967; Baumol et al., 1985). This refers to a stylized fact of economic growth that the transition into a services-intensive economy historically was associated with a marked growth slowdown (hence the oft-voiced concerns in developing countries about de-industrialization).

In a nutshell, post-industrial economies feature a rising share of services in GDP and at the same time experience a rise in relative costs of services. One reason for this effect is that services are much harder to scale than manufacturing.

Datafication changes everything for services-intensive economies because it introduces a highly scalable by-product of services that functions as a key factor input into the production of massively scalable AI (which has effectively a zero marginal cost of production). Human knowledge capital is not scalable; machine knowledge capital is (Ciuriak, 2018). Game changer.

Scalability introduces rents. Strategic behaviour is then inevitably induced since exercise of power determines market shares and the distribution of returns in the presence of rents. It has been oft remarked that we are in second "gilded age" (Krugman, 2014). The gilding is worth fighting over. Enter geoeconomics and geopolitics.

3.4 Data in the trading system

Data occupies a curious position in the trading system. On the one hand, insofar as it constitutes a digital product, it is subject to WTO rules, which are in principle technology neutral (see, e.g., Janow and Mavroidis 2019, s2). Moreover, insofar as data flows across borders are intrinsic to enabling a transaction subject to WTO commitments to take place, they are similarly subject to WTO commitments. In this sense, the term "electronic transmissions", which includes both data as the substance of the digital product and other data associated with transactions which accompany digital products and are intrinsic to the transaction if not the product itself, have always been fully subject to WTO rules.

At the same time, data is directly traded in a barter exchange that takes place outside the WTO system of rules. This takes the form of free Internet services in exchange for the data generated by the use of that service, which then can be monetized separately in the other side of a two-sided market[5]. Such data used to be "data exhaust" – now it is very valuable, constituting a large share of intangible assets.

In 1976, intangibles accounted for 16% of the value of the assets of companies that comprise Standard & Poor's S&P500 index. By 1995, when the WTO was founded, the share of intangibles had already risen above 50%. By 2018, this figure had risen to 84% (see Bloomberg figure below). The share of intangibles has now risen above 90%. S&P500 market capitalization peaked at over $40 trillion in August 2021; intangibles comprise $36 trillion of this amount.

Five US data-rich companies (Apple, Amazon, Facebook, Google/Alphabet and Microsoft) alone are worth about $9.5 trillion today, with most of that value comprised of intangibles. However, as

[5] Two-sided markets with one side operating on the basis of zero prices are a special type of market that has attracted attention from competition policy authorities in the context of the data-driven economy (OECD, 2018).

the aggregate figures for the S&P 500 show, the rise of intangibles is pervasive across industries. Notably, the United States International Trade Commission (USITC), in its quantification of the impacts of the Canada-US-Mexico Agreement (CUSMA), assigned a value of data flow to each of the over 100 industries in its analytical framework (USITC, 2019). US Trade Representative Katharine Tai echoed this in her statement: "Nearly every aspect of our economy has been digitized to some degree" (USTR, 2021).

Much of the value of intangible assets is comprised of data and associated assets (e.g., algorithms), although exactly how much is hard to determine (Ciuriak, 2019). This reflects the way that data is captured: there are no invoices or receipts to establish a transaction value. By the same token, the value of data is not found in national economic or trade accounts. It is not part of the discussion of the WTO moratorium on the application of tariffs to electronic transmissions. And it is not part of the base of the calculation of MNE taxes to be apportioned to end markets under the OECD/G20 Inclusive Framework for MNE tax reform (Ciuriak and Eurallyah, 2021). And yet it is widely considered the most valuable commodity in the modern economy and a major trade interest for the digital powers. Data is different and this difference needs to recognized in the trade discussion.

Figure 3: Tangible and Intangible Share of Corporate Assets, S&P 500

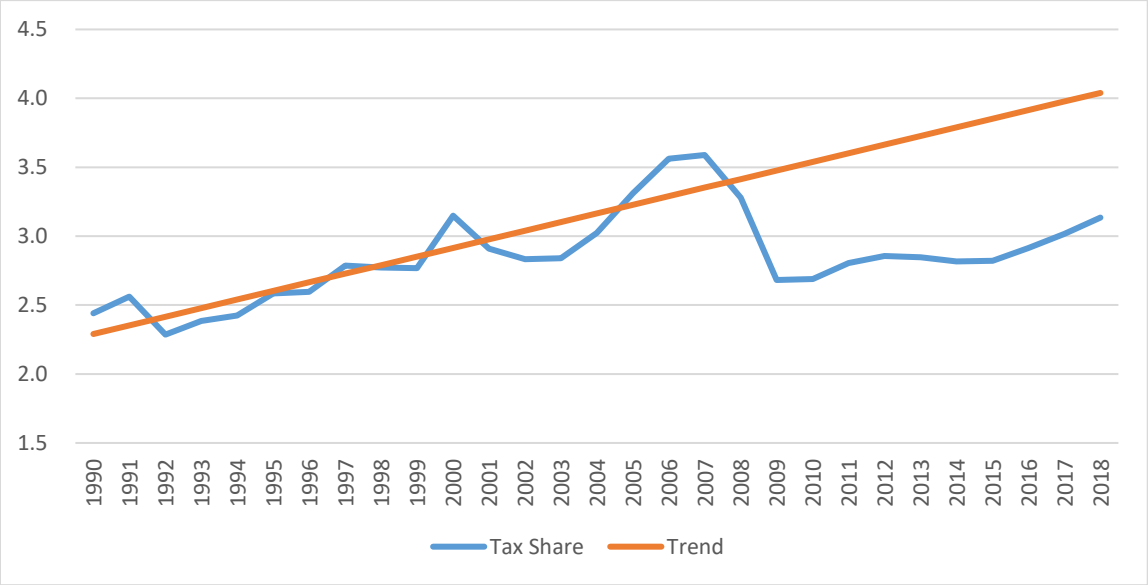
Source: Ponczek (2020).

3.5 Sharing the Rents – Trade Policy Becomes Tax Policy

Countries can benefit from the digital data-driven economy in two general ways – as a producer and as a consumer. Countries that can establish a foothold in this economy through data-driven companies that are able to operate both domestically and internationally can compete for the large international rents that this economy generates. In the absence of those firms, countries can still benefit as consumers from digital services that are, as noted above, often freely provided. However, they face poor terms of trade as they contribute to the development of global data assets but do not share in the ownership and exploitation of these assets. In a world dominated by intangible assets, consumer-only countries accordingly face a shrinking share of global wealth.

As one response, many countries have moved to impose digital services taxes, which led to the threat of retaliation, and ensuing negotiations to develop a global framework. The result is the OECD/G20 Inclusive Framework (OECD/G20, 2021; OECD, 2021). The redistribution of taxation rights is, however, very modest compared to the increase in the scale of profits shielded from tax through use of tax havens in the DDE era. Ciuriak and Eurallyah (2021) suggest that, for the OECD countries, the Inclusive Framework is a $150 billion solution to what has grown into a trillion dollar-plus tax avoidance problem in the DDE (figure 4).

Figure 4: Corporate Taxes as Share of GDP - OECD Average



Source: Ciuriak and Eurallyah (2021) based on OECD Corporate Tax Revenue Database. https://data.oecd.org/tax/tax-on-corporate-profits.htm

More importantly from the perspective of addressing rent capture in the DDE, the Inclusive Framework does not take into account the value of data. A lower bound for the value of data that is generated in the OECD region can be set at the value of free Internet services (which represent the other half of the barter-type exchange of free services for data). An estimate of this for the United States suggests it is on the order of 2% of GDP (Nakamura et al., 2018). For the OECD, this would imply about $1.2 trillion in value annually, of which two-thirds or over $800 billion would be generated outside the United States.

The amount of tax rights transferred under the Inclusive Framework ($125 billion) seems very small compared to the value of data captured. At an OECD average capital gains tax of about 20%, this calculation implies about $160 billion in shifted revenues. Clearly, this is a prize that is worth fighting over. It is implausible that countries will continue to allow it to flow across borders without compensation of some sort. The articulation of policies of "data sovereignty" etc., comes hardly as a surprise. Moreover, of the $125 billion in taxing rights reallocated, relatively little will go the developing countries – hence the issues surrounding the digital services tax/moratorium on electronic transmissions may not be settled.

4 Strategic Behaviour in the DDE

The DDE is an economy primed for strategic behaviour by countries and firms. Strategic behaviour is generally not analytically tractable, which makes this economy uncommonly hard to predict.

Superstar firms often have resources at their disposal that exceed most countries' R&D budgets yet are run by individuals who might be inclined to send a sports car with a mannequin in the driver's seat into space (Gunter, 2018).

Competition issues are pervasive with strategic behaviour; again unpredictability reigns since conditions of competition are shaped by agreements not markets. By the same token, competition becomes the new market access given the implications for market concentration and risk of anti-competitive behaviour (i.e., a firm's market access will tend to depend on the conditions it agrees to regarding competition concerns).

Innovation issues add to the uncertainties as the industrialization of learning through machine learning accelerates innovation and product life cycles shrink; and as the resources available for innovation become scalable – the first issue of a patent to an AI in 2021 (Naidoo, 2021) is an important marker in this latter regard.

IP protection is now centred on trade secrets, which have an indefinite duration, are non-transparent, and are proliferating – Taiwan's star computer chip manufacturer, TSMC, recently announced it had classified more than 140,000 trade secrets (Schindler, 2021). This is "do it yourself" IP protection. The rise in uncertainty for potential competitors as to the lie of the land is considerable.

Nation states are, under such circumstances, likely to identify their interests with their superstar firms - at least in international contexts – and to add their own strategic behaviour to the mix. The DDE was primed for strategic competition – and the pivot of China to technology delivered it.

China made its entry into the KBE at about the same time as it entered the DDE and made extraordinary progress on both, setting the stage for the strategic competition that blew up in the late 2000-teens.

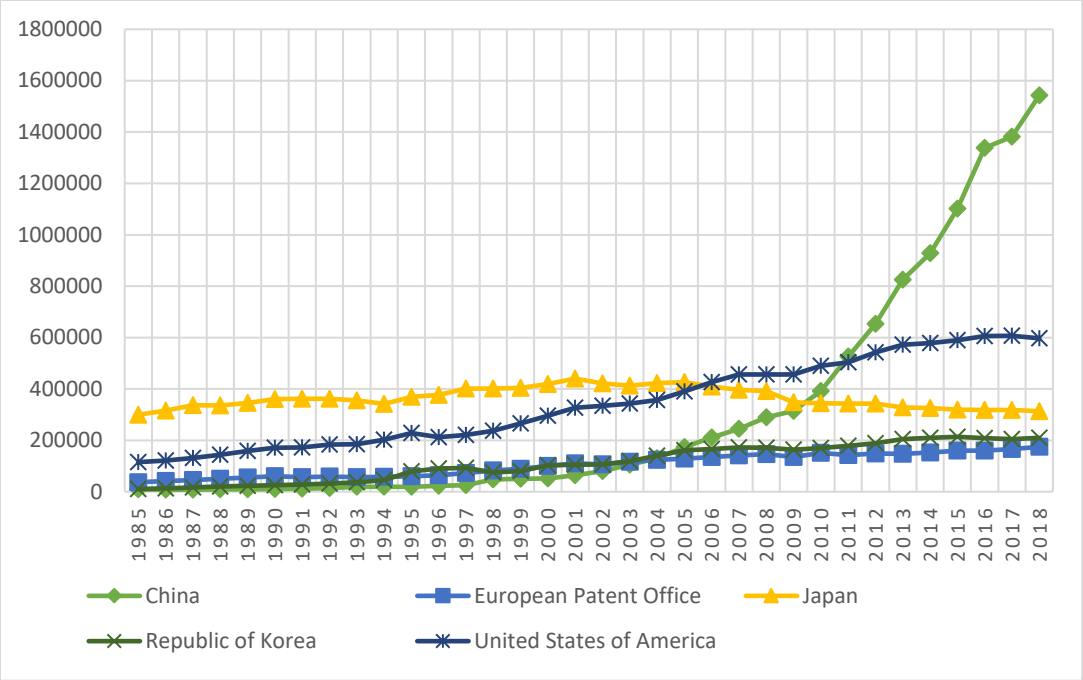
China's patenting activity really takes off around 2010 (Figure 5); this means it enters the KBE at the start of the DDE. Its participation in the KBE was supported by a steady rise in R&D as share of GDP; a substantially expanded IP infrastructure (thousands of patent examiners, specialized IP courts); much strengthened IP protection; and sophisticated strategies focussing on standards-essential patents (Ciuriak, 2017b; Ernst, 2017).

At the same time, e-commerce revenues as a share of total retail sales rose steeply following Apple's release of the iPhone 3 in China in January 2008 - China's mobile phone consumers transitioned en masse to smart phones and the rest is history as regards China's surge into global leadership in ecommerce (Figure 6).

China's cross-border data flows soared (Figure 7) and it joined the competition to capture international data flows through the development of the infrastructure of the DDE (submarine cables; Figure 8).

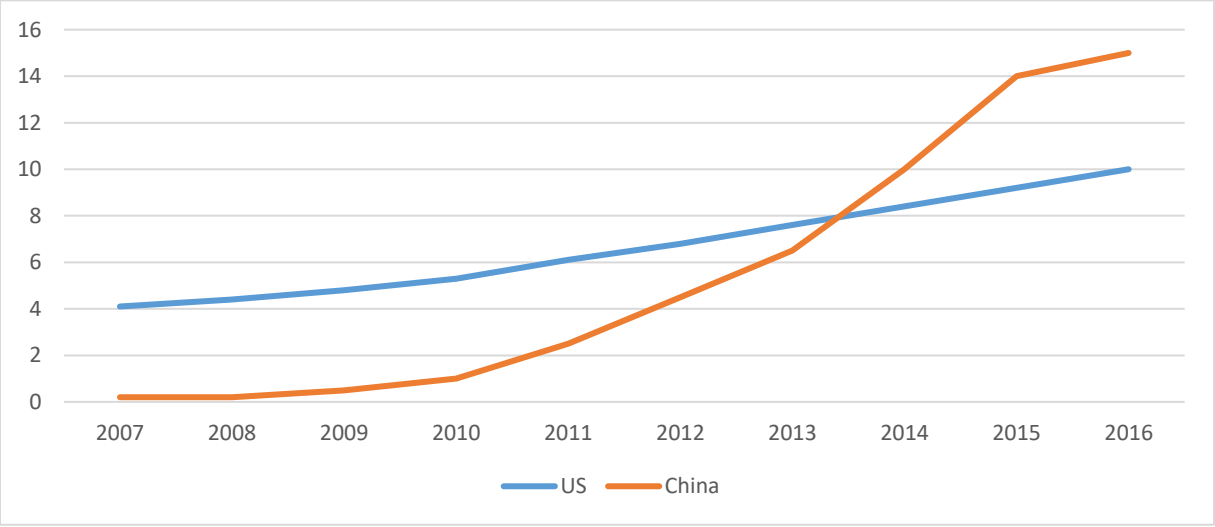
China's interests thus evolved rapidly in the past decade – its interest in joining the Digital Economic Partnership Agreement (DEPA) and the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP) should not come as a surprise (Asia Watch, 2021).

Figure 5. Total Patent Applications of the Top-5 Offices, 1980-2016



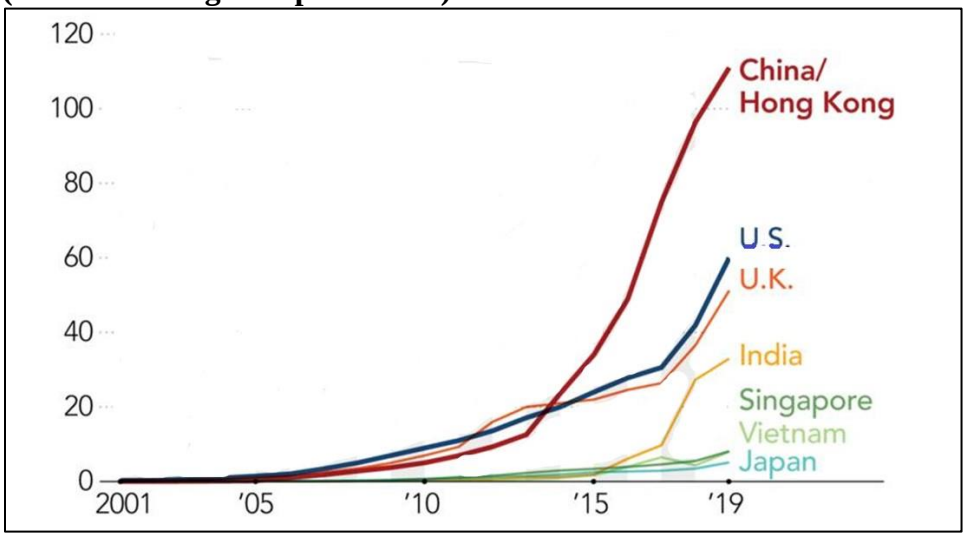
Source: World Intellectual Property Organization (2020).

Figure 6. E-commerce Revenues as Share of Total Retail Sales, 2007-2016



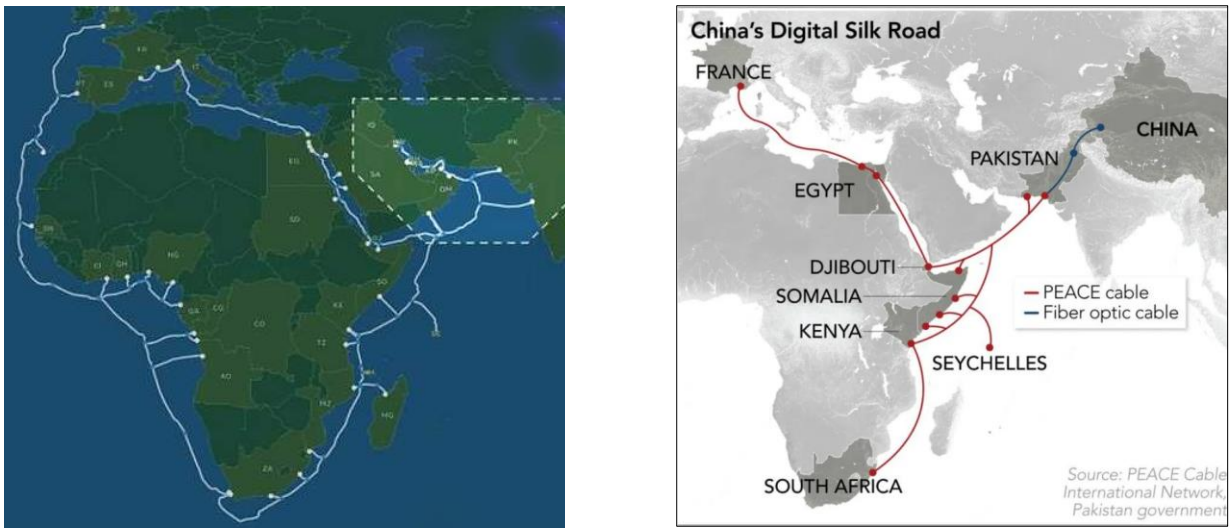
Source: Reproduced from Zhang and Chen (2019), based on Alibaba data.

Figure 7: Cross-border Data Flows by Economy, 2001-2019 (millions of megabits per second)



Source: Adapted from Tsunashima (2020), based on data from the International Telecommunications Union.

Figure 8: Facebook-backed 2Africa Cable and China's Digital Silk Road Africa Connections



Source: 2Africa cable chart from https://www.submarinenetworks.com/en/systems/asia-europe-africa/2africa; China's Digital Silk Road from Haq (2021).

The US "pivot to Asia" under the Obama Administration in 2009 seems to have had little to do with China's early engagement in the KBE/DDE. In particular, the militarization of the response indicates a conventional (and dated from the present perspective) view of geopolitics. Moreover, the early phase of the trade and technology war waged by the Trump Administration focussed principally on industrial goods. The development that appears to have served as the wake-up call that would drive the technology war was the realization by US strategists that the United States had fallen behind in the development of 5G telecommunications networks, which had profound implications for economic and military capabilities (Blustein, 2019: 247). The US pivot then became a pivot to technology. So, was it national security or rent-seeking? Possibly both, but the timing suggests the latter and the identification problem is inherently impossible to solve.

5 Discussion

Industrial policy is front and centre today in public policy discussions for a range of reasons.

First and foremost, the nature of the DDE puts in play what appear to be massive economic rents that countries are maneuvering to capture. Strategic trade and economic policy is back in vogue.

Second, the major societal challenges today are in public goods space (climate change, pandemic, digital transformation). The economics of public goods hasn't changed – there is in that sense no new "doctrine". The rationales for public sector engagement in the economy as regulator or in supporting production (including as a producer through state-owned enterprises) remain as they were, based on externalities and market failures (for a review, see Ciuriak, 2013). However, the nature of the major challenges means the optimal share of public goods in production has risen.

Third, the pandemic excited much political action to pull back from the globally distributed "made in the world" production system that emerged under the WTO, including through reshoring of supply chains. In a similar vein, the flaring of a cold war between the United States and China prompted initiatives by the United States to slow China's technological advance, in good measure by denying access to technology produced using US inputs. There has also been much discussion of "ally-shoring" to eliminate exposure to possible weaponization of supply chain linkages. These measures also involve industrial policies, in this cased based on over-riding national security concerns to both deny economic activity that the market finds profitable and to support economic activity that the market has judged inefficient.

Fourth, the acceleration of innovation means that more investments now feature risk-return metrics that fall outside the specifications required by private investors due to shortened time horizons to recoup outlays. By the same token, this means more investments that might have social utility are left on the table as it were, if governments stick to the OECD consensus that they only engage in industrial policies of a "horizontal" or "soft" nature rather than sector/firm/product-specific "vertical" or "hard" nature (the latter policies are pejoratively labelled as "picking winners").

Finally, the advances made in artificial intelligence mean the world is poised for steeply rising deployments of machine knowledge capital to complement or replace human knowledge capital. Since machine knowledge capital is eminently scalable (while human knowledge capital is eminently not), the large services-intensive sectors of the advanced economies will see technology-driven changes that will generate significant rents (even as they come to the rescue for aging economies and more generally free services-intensive economies from the Baumol effect which explains why the transition into a services-intensive economy is accompanied by slowing growth and declining productivity).

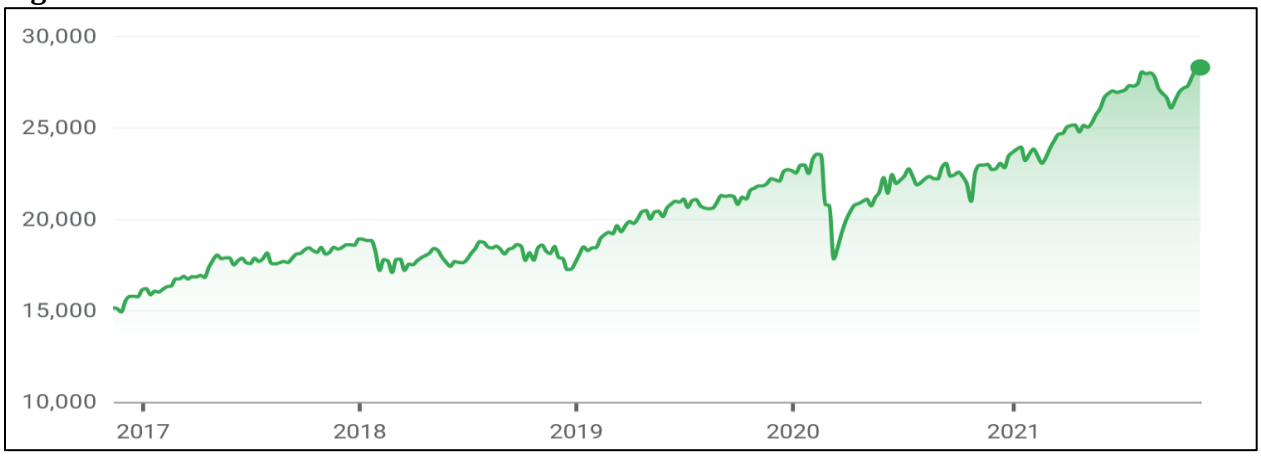
In the latter regard, China's path to the technology frontier is open based on the investments it made in its technology infrastructure in the 2000-teens. US restrictions on China's access to technology have repeatedly redounded. Necessity is the mother of invention and China has demonstrated its ability to invent. Following an incident in which China claimed the United States interfered with China's use of the GPS telecommunications network (Xie, 2020), China put in place its own BaiDou network (Lague, 2013; Crichton, 2020). When the United States excluded

China from the International Space Station (Kluger, 2015), China built its own (Kharpal, 2021) and for good measure recently executed a Mars lander on its first try (Webb and Allen, 2021) and brought back the first lunar samples in 44 years with its Chang'e 5 mission in 2020 (Crane, 2020). Quantum computing is on the list of technologies subject to US export controls: Scientific American reported this year that China is now leading in this area (Garisto, 2021) – after having launched the first quantum experimental satellite in 2016 (Gibney, 2016), and conducted the first successful quantum entanglement experiment at that distance in 2017 (Billings, 2017).

The US restrictions on computer chips and computer chip manufacturing technology likely face the same fate. There is much industry commentary to the effect that China has already gained full capability for mature 28 nanometer production technology as of 2021 and will have mass production capability of 14 nanometer chips – which constitute the backbone of chip applications – by end-2022 (see, e.g., Verdict, 2021; Barton 2021).

While it is impossible to know the state of play in tech due to the rapid pace of development, the market valuation of China's leading semiconductor manufacturing firm, SMIC, which was targeted by US sanctions, compared to Intel which is a beneficiary of these restrictions, provides a real-time guide (Figures 9 and 10) as to what the market, however misguided it might be, thinks.

Figure 9: Market Performance of SMIC



Source: Google Finance, accessed 16 November 2021

Figure 10: Market Performance of INTEL

Source: Google Finance, accessed 16 November 2021

Whether or not markets are truly efficient (in the sense of incorporating all known information and acting rationally on that information), they do reflect assimilation of a vast amount of public and private information. As well, FDI is flooding into China (up 17.8% in the first 10 months of 2021 after China led the world in 2020).

Rents aren't going away. Public goods issues aren't going away. China is not going away. And the United States is hardly likely to throw in the towel. The post-pandemic DDE will thus be shaped by sustained high-stakes industrial policy competition.

Bottom line: changing technological and economic conditions mean that the rules-based system developed for the mature industrial economy and emerging KBE is not set up to govern the DDE. This would be the case even absent the major societal challenges and the growing geopolitical/geoeconomic divide. When the latter considerations are taken into account, the need for a wholesale review of the system becomes crystal clear.

Whither Canada? As a small open economy that depends on its relations with a global trading system in an innovation-intensive economy, the answer is hardly novel.

On the trade front, the escalating resort to national security rationales for trade restrictions represents a threat to Canada's prosperity. Canada's optimal response is to circumscribe the use of this justification to the extent possible and to restore multilateral disciplines to ensure that they are available when such measures are invoked. Otherwise, Canada should pursue its traditional policy of economic diplomacy in the United States to combat protectionism in our main market and to seek trade diversification opportunities where they present themselves.

As regards innovation, Canada starts from a weak position with R&D spending as a share of GDP well below the OECD average, a relatively small number of unicorns in an age of unicorns, and a problematic structure of international trade specialization – a trade surplus in R&D services and a deficit in the IP that results from R&D, with a large net negative.

In an innovation-intensive world of superstar firms and geostrategic competition, the focus should be on innovation and firms. The measure of success: Canada's count of unicorns would be rising steeply, as would be Canada's R&D share of GDP, and private and public venture capital support for Canadian technology-intensive companies would be breaking records.

Canada's economic history is punctuated by the establishment of Crown Corporations to fill gaps. The maturation of the industrial era economy may have given the impression that this was history. Today, it's not a question of necessarily resorted to Crown Corporations, but Canada should not hesitate to go that route if necessary.

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