Innovation in Canada

An Assessment of Recent Experience

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Contents

Executive Summary

For decades, the Canadian federal government, as well as provincial governments, have implemented policies to promote commercial innovation. Notwithstanding, it is widely acknowledged that Canada's innovation performance has been, and remains, relatively weak by international standards. Indeed, Canada's performance relative to national innovation leaders, as well as to the United States specifically, has deteriorated in recent years after showing some improvement from around 2007-2012.

Innovation is critically important to a nation's economic welfare, since innovation plays a crucial role in promoting productivity growth. In turn, productivity growth underlies improvements in an economy's standard of living.

In this study, we compare Canada's innovation performance over approximately the past decade to that of other developed countries using two well-known indices of innovation. Innovation can be broadly thought of as the process by which new products, new methods of production, and new organizational structures and managerial techniques are introduced and used in an economy. Numerous individual measures of innovation have been cited in the literature, although no single measure is clearly preferable. Hence, most scholars favour using indices that combine a number of different individual measures. We use innovation indices reported in the *Global Competitiveness Report* and the *Global Innovation Index*. Both indices provide similar insight: Canada's relative innovation performance has worsened in recent years.

The study augments the evidence from the innovation indices with information about the relative performance of Canadian firms in terms of their growth of sales revenue and profits. Since innovation improves competitiveness, innovation should be linked ultimately to improved sales and profit performance. Available data from *Fortune* magazine identifies the 100 fastest growing companies on an annual basis. From 2007 through 2012 there were significantly more Canadian firms on *Fortune's* list than is the case after 2012. Hence, the information from *Fortune's* list of the fastest growing companies supports the observation drawn from the innovation indices. Namely, Canada's innovation performance has deteriorated in recent years.

Various evaluations of Canada's innovation experience link its relatively poor performance to weakness in private sector expenditures on research and development and a lack of success on the part of start-up firms in converting technological opportunities into commercially successful technological outcomes. However, there is substantially less agreement about the causes of this phenomenon.

To date, government policy has largely focused on subsidizing the innovation activity of Canadian companies through tax credits of various sorts, as well as direct funding programs. The federal government's Innovation and Skills Program focuses, in part, on providing increased venture capital funding for companies in later stages of the start-up process. It also includes financial measures to increase worker training and ease the transition from part-time to full-time work, as well as financial incentives to create mega-clusters in specific industrial activities, among other initiatives.

While the federal government's focus on improving the transition of Canadian companies from start-ups to successful anchor firms in international technology ecosystems seems well placed, public policy as it is directed toward improving innovation still remains what might be characterized as "top-down." Specifically, even though the federal government is streamlining its bureaucracy in the context of its innovation support programs, it continues to play a major role in directing the allocation of resources in the technological change process, primarily through taxpayer-funded programs of various sorts.

This top-down approach has been unsuccessful over a sufficiently long period to justify a substantial rethinking of innovation strategy. An alternative approach would emphasize altering both the incentives and financial and related resources of the private sector, so that innovation in Canada becomes more of a "bottom-up" phenomenon. For example, more emphasis might be placed on promoting domestic competition, primarily by reducing barriers to foreign direct investment in critical infrastructure industries such as telecommunications and banking. Increased competition should strengthen the incentives of private sector firms to improve their competitive position in the marketplace. The *Global Competitiveness Report* highlights the negative influence that government regulation has on innovation in Canada compared to countries that are more successful at innovating. It also identifies Canada's tax structure as being relatively unfavourable for encouraging innovation. In this regard, numerous studies provide evidence that reducing marginal personal tax rates and the capital gains tax rate will promote innovation by increasing incentives for the private sector to take risk and by enhancing internal sources of capital funding.

> Since 1916… the main objective of Canadian science policy has been to promote technological innovation by industry… Almost every decade since the 1920s has witnessed renewed attempts by successive governments to achieve it, but on the whole they have all failed.
>
> —*Source: Senate Special Committee on Science Policy (1970) as quoted in Council of Canadian Academies (2013).*

1. Introduction

As the preceding quote implies, identifying and implementing policies to promote innovation in Canada has been a long-standing focus of Canadian government policymakers. Most recently, the government of Canada introduced its "Innovation and Skills Plan" in its 2017 budget.[1] The objective of the program is to build Canada as a world-leading innovation economy.

Over the years, numerous government-appointed councils and commissions have documented Canada's innovation gap and tried to explain the reasons for that gap.[2] While there is general agreement that Canada's innovation performance in the past has been weak compared to that of many other developed economies, there is much less agreement about why Canada performs relatively poorly.

Canada's innovation performance is critically important to the economic welfare of Canadians. Innovation plays a critical role in promoting increased productivity, which, in turn, underlies improved standards of living. Crafts (2008) notes that in the long run, the key to sustained multi-factor productivity growth is innovation.[3] The policy relevance of Canada's innovation performance is therefore underscored by the fact that there has been virtually no growth in multi-factor productivity in Canada over the past decade (Statistics Canada, 2018a).

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[1] See Canada (2017). We shall discuss the program in more detail in a later section of this report.

[2] For example, the various reports of Canada's Science, Technology and Innovation Council are summarized in Wells (2015).

[3] Multi-factor productivity growth effectively measures the increased real output produced by the services of capital and labour.

This report aims to provide and assess data on Canada's recent innovation performance. We reference several well-known published "league table" measurements of innovation, which rate countries according to multiple indices of innovation performance. Since there is no clear consensus on which specific individual measures of innovation are most meaningful from a policy perspective, the use of league tables based on multiple measures of innovation performance seems appropriate. Evaluating assessments that draw upon a variety of different measures of innovation can help identify precisely where in the chain of activities contributing to innovation Canada performs relatively well and relatively poorly. This identification can presumably assist policymakers to leverage Canada's strengths and mitigate its weaknesses.

We acknowledge at the outset that there are numerous studies providing different metrics related to innovation in Canada, and we review some of those studies in the context of the data that we present. Our contribution to the literature is first that it focuses on recent innovation experience. Determinants of innovation performance may vary over time, so recent data are important as a guide to policymakers. Second, we assess Canada's recent innovation performance relative to the countries considered innovation leaders. While the United States is one such country, our data sources identify other, smaller countries, most notably Switzerland, as innovation leaders for much of our sample period. Third, we look at Canada's relative performance across different attributes that potentially contribute to productivity growth more generally, and innovation performance more specifically. This detailed evaluation of the broader environment for productivity growth and technological change is likely to produce more relevant policy insights than an evaluation of the innovation process narrowly defined.

The essay proceeds as follows. Section 2 discusses various measures of innovation that have been cited in the literature as well as their strengths and weaknesses. It identifies the potential advantage of using index values that aggregate different individual measures of innovation. Section 3 reviews Canada's recent innovation performance against that of other countries using comparative data known as league tables. Section 4 identifies Canada's strengths and weaknesses in innovation using the data in two major league tables. It also considers Canada's contribution to fast growing global companies. Section 5 evaluates explanations that have been offered for Canada's relatively poor innovation performance, along with some policies that have been recommended to improve that performance. The final section provides concluding comments and several policy recommendations.

2. Measuring Innovation

Obviously, any empirical description of innovation activity in Canada must first address the issue of how innovation is meaningfully measured. Most definitions focus on business activity. In this regard, a general definition of innovation in the business sector encompasses the implementation of a new or significantly improved product or process, a new marketing method, or a new organizational method in business practices, workplace organizations, or external relations (Gault, 2018). It is important to emphasize that key feature of innovation is that it must have been implemented. A new or improved product is implemented when it is first introduced in the marketplace. New processes, marketing methods, or organizational methods are implemented when they are brought into actual use in the firm's operations. Implementation distinguishes the innovation stage of the technological change process from the invention stage. Invention, which is the earliest stage of the technological change process, encompasses the creation of new products and processes.

Gault (2018) notes that a focus on private firms excludes innovation that occurs in the public and non-profit sectors. Hence, he suggests a modest broadening of the definition of innovation. Specifically, he suggests defining innovation as a new or significantly changed product that is made available to potential users, or a new or significantly changed process that is brought into use in the operation of an institutional unit, be it for-profit, government, or not-for-profit.

This latter definition of innovation highlights the extreme difficulty in directly measuring innovation activity as defined above. New or modified products and processes are being introduced all the time, and there is no practical way to measure directly the rate of introduction across organizations for national economies.[4] Furthermore, even if government agencies could measure the introduction of new or modified products

[4] Reeb (2017) highlights the small number of firms that make regular announcements about the introduction of new products and processes. Statistics Canada (2018b) asks Canadian firms in a survey if they have introduced a new product or process in the past few years. This, at best, is an indirect measure of innovation that will be discussed further in a later section.

and processes, issues would arise about the technological or commercial significance of the innovations identified.

Since direct measurement of the quantity and significance of innovation is impractical at a national level, governments and non-governmental organizations such as the Organization for Economic Cooperation and Development (OECD) employ a variety of indicators that are conceptually related to innovation activity. For example, the OECD's *Oslo Manual* reports a broad set of national measures that are viewed as being related to innovation, including intramural R&D spending, science and technology personnel, patents, scientific and technological publications, and citations and exports of high technology products.[5] Other measures of innovation include acquisition of technology from outside the country, investments in machinery and equipment and other capital goods, trademarks registered outside the country, and productivity growth (OECD, 2011).

Virtually all of the various individual measures of country-level innovation have flaws. It is beyond the scope of this paper to discuss in detail the problems with individual indicators of innovation. In broad terms, a number of the standard measures, such as R&D spending, and science and technology personnel, are inputs to the innovation process. While such inputs, in theory, should be related to innovation, the relationship need not be constant across countries. Other measures such as the number of scientific publications, patents, and trademarks can be seen as indicators of knowledge creation, but they do not provide reliable signals of innovation at the economy-wide level. For example, Hall, Helmers, Rogers, and Sena (2013) note that while pharmaceutical firms view new patents as an important tool in the innovation process, most other firms see them as relatively unimportant and rely on trade secrets to protect their proprietary technology.[6] Moser (2013) concludes from historical evidence that in countries with patent laws, the majority of innovations occur outside the patent system. Countries without patent laws have produced as many inventions as countries with patent laws during some periods of time, and their innovations have been of comparable quality.

Output measures also are imprecise indicators of innovation activity. For example, productivity growth rates incorporate the influence of technological change, which is certainly related to innovation, although it also reflects other factors such as economies of scale and the skill level of the workforce. Exports of high-technology products will reflect innovation

[5] See Hao, van Ark, and Ozyildirim (2017) for a discussion of the many measures that are used in inter-country comparisons of innovation activity.

[6] Moser (2005) reports that most inventions remain unpatented, but those that are patented are some of the most successful.

activity, but they will also reflect other determinants of trade such as tariff and non-tariff barriers among trading partners.

In sum, numerous individual measures of innovation have been used in empirical studies, but all of the measures have important weaknesses. As such, Reeb (2017) and others have recommended using multiple measures in combination to derive a multi-variable index, although opinions can differ about precisely what measures to combine. In this context, it seems advisable to draw upon multi-variable indices that are in the public domain and that are widely cited in the relevant literature. In this study, we draw upon two well known "league tables" that compare the innovation environment across countries using multiple indices. One is the *Global Competitiveness Report* produced by the World Economic Forum. A second is the *Global Innovation Index* co-published by Cornell University, INSEAD, and the World Intellectual Property Organization.

The *Global Competitiveness Report* (GCR) identifies and measures factors that experts believed determine productivity, which is the main driver of economic growth. The overall measure of competitiveness is reported as the *Global Competitiveness Index* (GCI). The GCI combines 114 different indicators capturing country attributes that are important for productivity. The indicators, in turn, are grouped into 12 "pillars," of which the pillar of most direct interest is "innovation."[7] The innovation pillar consists of the following indicators: 1) capacity for innovation; 2) the quality of scientific research institutions; 3) company spending on R&D; 4) university-industry collaboration; 5) government procurement of advanced technology; 6) the availability of scientists and engineers and 7) patent applications. Each of the indicators is ranked on a scale of 1-7, as are each of the pillar scores.[8]

Innovation is an important contributor to productivity, and productivity underlies improvements in standards of living. In this regard, the *Global Competitiveness Report* provides insight into how well Canada is

[7] The other pillars are institutions, infrastructure, macroeconomic environment, health and primary education, higher education and training, goods market efficiency, labour market efficiency, financial market development, technological readiness, market size, and business sophistication. The indicators and their grouping are discussed in Schwab and Sala-i-Martin (2017). Note: we used the Global Competitiveness Index Historical Dataset, 2007–2017 for the data included in this report.

[8] The indicator values are based on statistical data from international organizations and responses from the World Economic Forum's *Executive Opinion Survey*. The indicators themselves reflect the judgment of experts as to the main determinants of innovation. The components of any aggregated index of innovation can be challenged as being incomplete or inappropriately weighted. This does not gainsay that they are improvements upon individual indicators.

doing relative to other countries on a host of other factors that influence productivity. This insight is potentially valuable in identifying whether government programs related to indicators positioned in other pillars, such as worker training and delivering digital skills in primary and secondary schools, are likely to address areas of weakness in Canada's innovation performance.

The *Global Innovation Index* (GII) provides a database of detailed metrics that rank world economies' innovation capabilities and results. It uses 79 variables to measure innovation through the creation of two sub-indexes: the innovation input sub-index and the innovation output sub-index. The first covers institutions, human capital and research, infrastructure, market sophistication, and business sophistication. The second covers creative outputs and knowledge, and technology outputs.[9] The overall GII score is the simple average of the input and output sub-indices, and it is the measure of innovation that we rely upon.

In the next section, we review data from these two well-known multi-factor league tables of innovation. We also compare the data to findings from several other surveys. The data point to a deteriorating innovation performance by Canada relative to innovation leaders.

[9] See the *Global Innovation Index, 2018 Report* at https://www.globalinnovationindex.org/analysis-indicator. We use different volumes of the *Global Innovation Index*. For convenience, we do not provide the URL for each volume we use, but all can be accessed from the home page of the link given above.

3. Canada's Recent Innovation Performance

As noted above, the GCI is an overall index of national competitiveness, which is essentially an overall assessment of the productivity of an economy. The GCI is a useful basis for assessing the importance of innovation to overall competitiveness, since other factors besides innovation can contribute to a country's productivity performance. Ultimately, productivity performance determines standards of living. While innovation certainly contributes to productivity performance, the GCI provides a broader basis (than innovation) for ranking the performance of national economies. The GCI, therefore, provides a useful overall perspective against which to assess Canada's performance on the innovation dimension relative to its overall productivity profile.

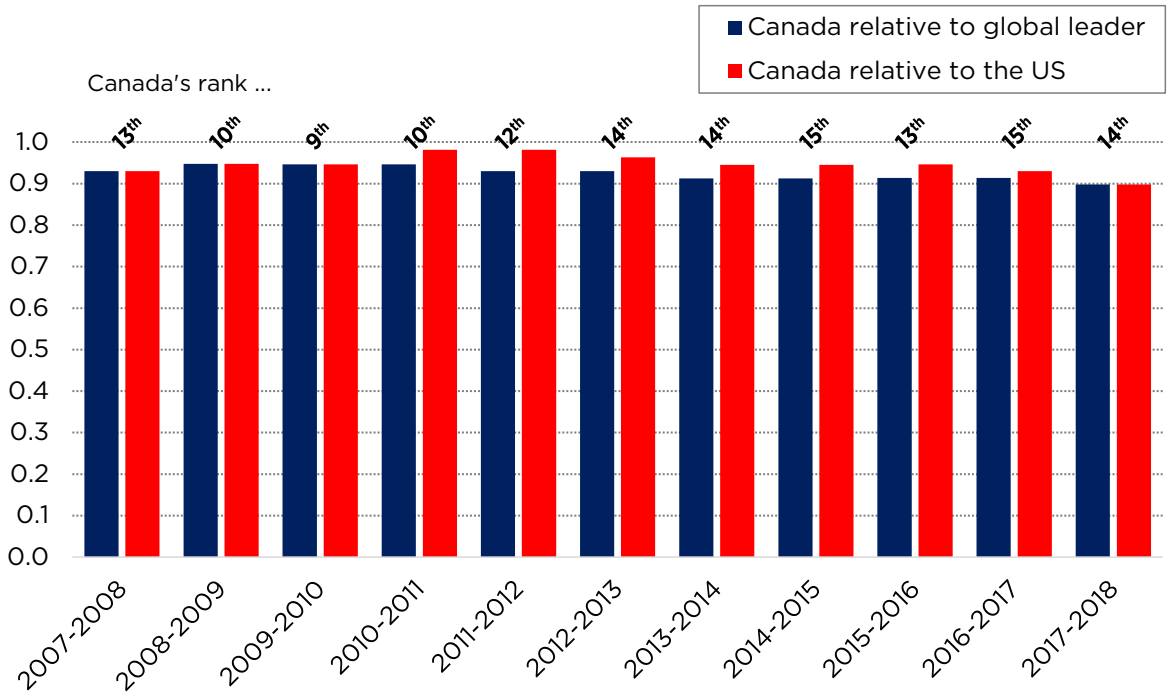
Measures from the *Global Competitiveness Report*

Figure 1 summarizes Canada's overall ranking on the GCI, the country's GCI score relative to the score of the global leader, and its GCI score relative to the US score.[10] These data are reported for the period 2007-2008 through 2017-2018. While GCI scores are available for earlier periods, our specific interest is in Canada's recent performance. Furthermore, changes to the methodology involving the number of pillars and sub-pillars in the 2007-2008 reported results make comparisons between years prior to 2007-2008 with later periods potentially unreliable.

The data reported in figure 1 show a modest improvement in Canada's relative international competitiveness over the period 2007-2008 to 2010-2011. Specifically, Canada moved up the international rankings of competitiveness over that period. It also improved its competitiveness score relative to the competitiveness leader over that period. Canada's

[10] Where the values of columns 2 and 3 are equal, it indicates that the US had the highest GCI score in that period. In all cases when the US was not the GCI leader, Switzerland had (or shared) the highest GCI score.

Figure 1: Canada's Performance on the Global Competitiveness Index, Relative to the Global Leader and the United States



Source: *Global Competitiveness Index Historical Dataset 2007-2017*, Version 20180226, World Economic Forum: http://reports.weforum.org/global-competitiveness-index-2017-2018/downloads/.

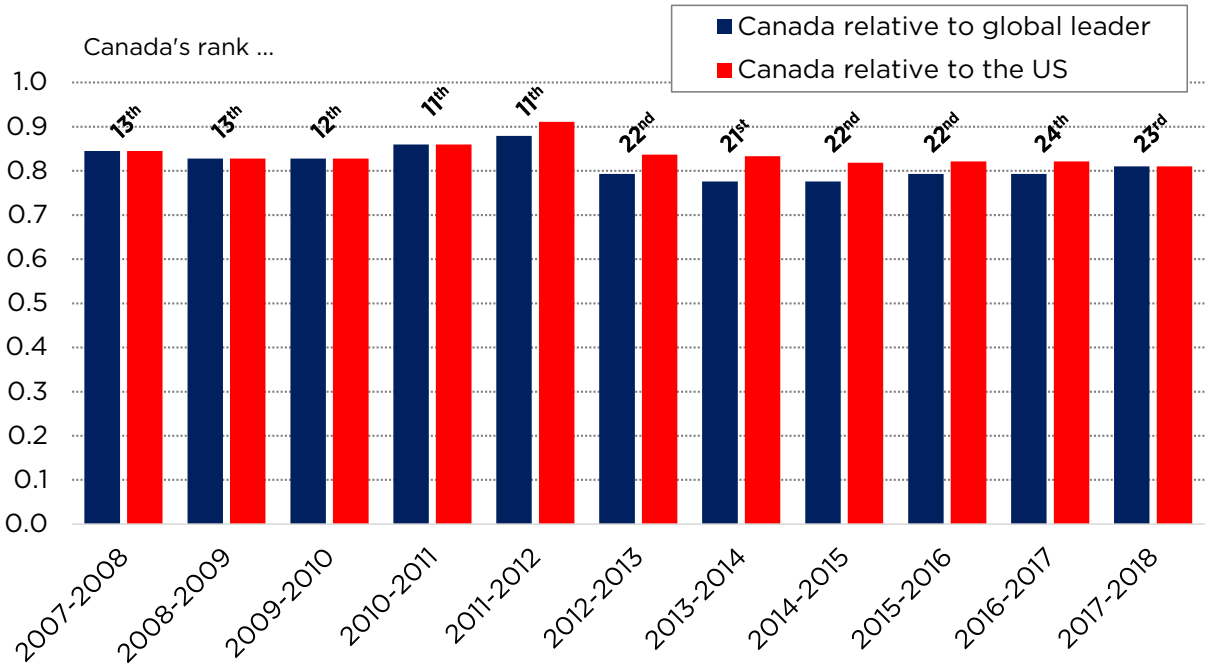
performance relative to that of the US also improved from 2007-2008 to 2010-2011. However, Canada's competitiveness performance clearly deteriorated after 2010-2011. In particular, by 2017-2018, Canada's competitiveness relative to the leader, as well as relative to the US, was lower than in any earlier sample period.

Appendix table A1 provides the raw data underlying figure 1, as well as Canada's ranking on the GCI score relative to other OECD countries. That ranking broadly supports Canada's deteriorating performance relative to other OECD countries in recent years.

Our particular interest is in Canada's innovation performance. Figure 2 reports Canada's ranking on the (GCR's) innovation pillar. Column 1 report's Canada's innovation score relative to the score of the highest ranked country for the period shown.[11] Column 2 reports Canada's in-

[11] For five of the sample periods, Switzerland was highest ranked for the innovation pillar. Finland, the United States, and Israel were also innovation leaders over the full period covered.

Figure 2: Canada's Performance on the innovation Pillar of the Global Competitiveness Index, Relative to the Global Leader and the United States



Source: *Global Competitiveness Index Historical Dataset 2007-2017*, Version 20180226, World Economic Forum: http://reports.weforum.org/global-competitiveness-index-2017-2018/downloads/.

novation score relative to the United States' score. Obviously, when the ratios in columns 1 and 2 are identical, the United States is the highest ranked country in that sample period.[12]

Canada's improvement in its innovation performance in the early part of the sample period corresponds to the improvement in its overall competitiveness performance. Specifically, Canada's rank and its performance relative to the innovation leader improved between 2007-2008 to 2011-2012. However, there is a dramatic drop in Canada's performance in 2012-2013 and a more modest decline in 2013-2014. After 2014, Canada's performance relative to the technological leader improves slightly, while it deteriorates slightly relative to the United States.

Appendix table 2A underscores Canada's relative deterioration in innovative performance after 2011-2012. Specifically, the last column of the table reports Canada's rank relative to other OECD countries with respect

[12] Switzerland, Israel, and the US have the same values for the innovation pillar in 2017-2018.

to its performance on the GCR's innovation pillar. The substantial drop from 2011-2012 to 2012-2013 is again notable. Moreover, there is virtually no recovery in Canada's OECD ranking throughout the remainder of the sample period.

The relatively substantial decline in Canada's innovation performance between 2011-2012 and 2012-2013 merits some discussion. We looked at the behaviour of each of the sub-pillars associated with the innovation pillar for the two periods. Relative to Switzerland, the innovation leader, Canada's performance worsened between the two periods for all six of the sub-pillars for which we had full data. In addition, in 2012-13 PCT patent applications[13] per million population were added; Canada's value averages about 25 percent of Switzerland's. Canada's performance relative to the US declined for four of the six available sub-pillars. However, Canada actually improved its performance in availability of scientists and engineers compared to the United States. Canada's value for the seventh sub-pillar, PCT patent applications (data starting in 2012-13) averages roughly half of the US value. Even if the addition of patent data in 2012-13 is viewed as a break in the series, Canada's performance also worsened on all the other sub-pillars relative to Switzerland between 2011-12 and 2012-13. Further, Canada's innovation values worsened relative to the United States even after the inclusion of patent data.

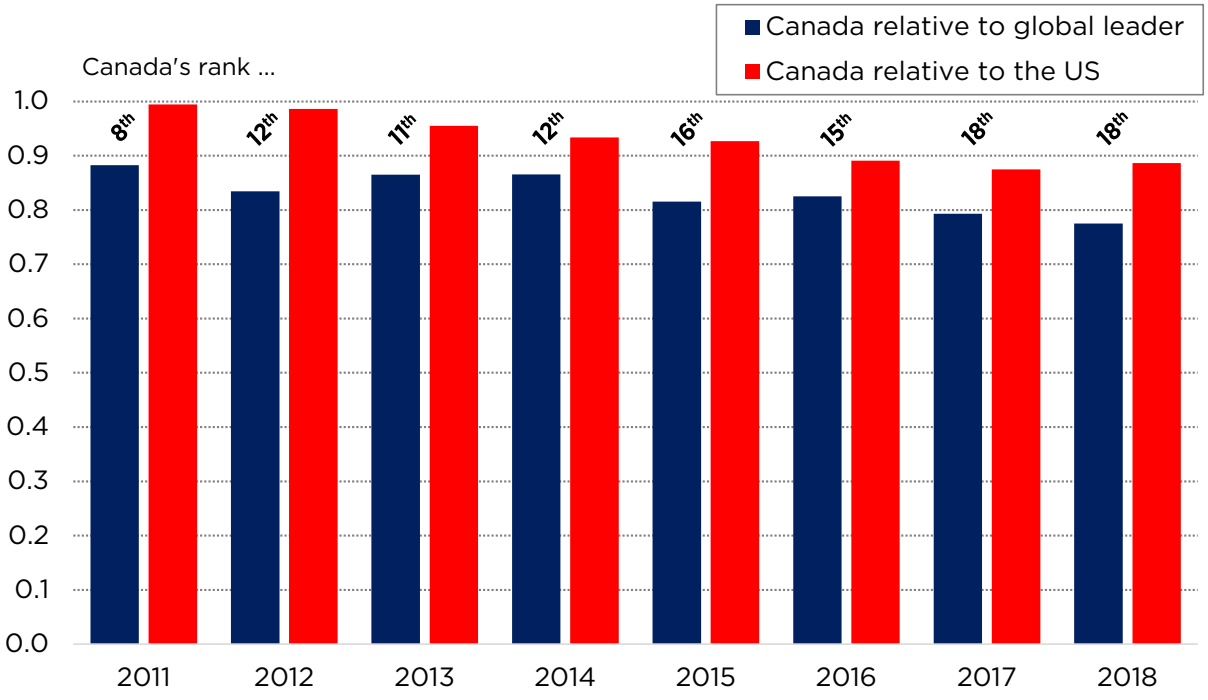
Measures from the Global Innovation Index

The sensitivity of the league table results for innovation from the GCR to specific measures (or sub-pillars) of innovation suggests the wisdom of looking at other multi-attribute measures of innovation across countries. The *Global Innovation Index* (GII) is another such league table.

Figure 3 reports data similar to that of figure 2 using the GII. Specifically, figure 3 reports Canada's rank on the index, the ratio of Canada's index value compared to the country with the highest index value, and Canada's index value relative to the index value for the United States. Methodological differences from earlier years mean that individual calendar years are reported only beginning in 2011. The year-to-year patterns in the ratios reported in figure 3 differ between the two measures of relative innovation performance. However, what is common to both measures is that Canada's innovation performance relative to the innovation leader,

[13] The Patent Cooperation Treaty (PCT) is an international system that enables applicants to file one patent application for their invention in a large number of countries.

Figure 3: Canada's Performance on the Global Innovation Index, Relative to the Global Leader and the United States



Source: *Global Innovation Index* (2011 through 2018 reports): https://www.globalinnovationindex.org/home

as well as to the United States, is substantially worse in the latest period reported (2018) compared to around 2011. That is, both indices identify deteriorating innovation performance for Canada in recent years. Hence, both league tables identify a deterioration in Canada's innovation performance post-2011.

The last column of appendix table 3A reports Canada's rank relative to the other OECD countries on the GII measure. Once again, the decline in Canada's relative performance from 2011 to 2012 is noticeable. Appendix table 3A also shows that Canada's relative performance (measured by ranking) in the OECD sample, as in the sample of all countries, is substantially worse at the end of the sample period than in 2011.

4. Canada's Innovation Strengths and Weaknesses

The correlation between the indices

The innovation pillar score from the GCR and the GII provide a similar picture of Canada's recent innovation performance. Confidence in this inference would be strengthened if the two indices provided similar estimates of the innovation performances of other countries. To see if this is so, we chose a sample of the top 31 (developed) countries according to the GII. We then estimated a correlation coefficient between the GCR's innovation pillar score for 2017-2018 and the index value from the GII for 2018 for the sample of 31 countries. The correlation coefficient was .900, which suggests a very strong similarity in how the two indices rank countries in multi-variable measures of innovation.[14]

It would also be reassuring if we could know that the two innovation measures used to describe Canada's recent innovation performance were linked to the Global Competitiveness Index, since improved economic competitiveness is ostensibly the payoff to dedicating resources to innovation. For the 31 developed country sample, we estimated a correlation coefficient between the GII for 2018 and the GCI for 2017-2018. We also estimated a correlation coefficient between the GCR's innovation pillar index and the GCI for 2017-2018 for the 31-country sample. The former coefficient equals .835 and the latter equals .899.[15]

Since the innovation pillar is an important component of the GCI, it is not surprising that there is a strong correlation between the two met-

[14] We also converted the two index series into natural logarithms to reduce the potential for a high correlation to be the result of extremely high or extremely low index values for the same countries in each series. The correlation coefficient for the two series expressed as natural logs was virtually identical (.861) to the correlation coefficient for the two series expressed in their absolute values. All of the correlation coefficients reported in this essay are statistically significant at the 95 percent confidence level or higher.

[15] Appendix B lists the 31 countries.

rics. However, the strong correlation between the GCI and the GII variables provides additional support for the relevance of a linkage between a country's innovation performance and its competitiveness in the global economy.[16]

The empirical evidence presented in this section supports the following interpretation. Canada's competitiveness relative to other developed countries has declined in recent years, as has its relative innovation performance. Since changes in innovation performance are likely to lead to changes in competitiveness, Canada's recent decline in relative innovation performance suggests the possibility of future declines in Canada's international competitiveness. The federal government's concern with Canada's recent innovation performance as underscored by its Innovation and Skills Plan therefore seems well founded. Whether the changes implemented in the 2017 budget are appropriate will be addressed later in this essay. Before doing so, we present and assess some additional evidence on Canada's recent innovation performance.

Fastest growing companies

Firms that successfully introduce new products and production processes typically enjoy above-average growth rates. Hence, information on the extent to which Canadian companies enjoy relatively fast growth rates for revenues and profits provides some additional insight on the commercially oriented innovation performance of those companies.

Fortune magazine identifies the fastest growing companies in individual years based on revenues and profits.[17] The country headquarters of companies on the *Fortune* list provide some insight into the marketplace success those companies enjoy and, indirectly, into the innovation environment of the countries in which the companies are headquartered. To be sure, the growth of individual companies in any year can reflect factors that are exogenous both to the companies and the innovative environment of the countries in which they are headquartered. For example, mineral companies might appear on the list in a given year in which commodity prices increase substantially. Nevertheless, changes over time in the number of Canadian companies appearing on the list provide potential insight into changes in innovative activity in Canada.

16 A relevant caveat here, of course, is that correlation, however strong, does not necessarily identify causation.

17 The URLs for the relevant website vary by year. For 2017, the information can be found at http://fortune.com/100-fastest-growing=companies/2017/list.

We looked at the *Fortune 100* list for each individual year from 2009 through 2018 to identify Canadian companies that made the list. There were four companies on the list in 2009 and 2010. Research in Motion, the developer of the Blackberry mobile telephone, was on the list in both years, and it was the fastest growing company on the list in 2009. Six Canadian companies made the list in 2011, including Research in Motion and lululemon Athletica. The other four companies were in the mining and energy sectors.

The high point for Canadian companies being listed was in 2012 when nine Canadian companies made the *Fortune 100* list. Five of the companies were in the mining or energy sectors. Research in Motion did not make the list that year, although lululemon did remain on *Fortune's* list. Six Canadian companies made the list in 2013, while only two companies made the list in 2014.[18] In 2015 and 2016, no Canadian company appeared on the list, while only one company made the list in 2017 and two in 2018.

As noted earlier, while identification on a list of the world's fastest growing companies is an imperfect indicator of successful innovation activity, the information provided by the *Fortune 100* list is consistent with the data presented in figures one through three. Namely, Canada's innovation performance seems to have weakened after 2012.

[18] In 2013, five of the companies listed were in the resource sector. The sixth, lululemon, is in the athleisure apparel industry.

5. Innovation Performance Explanations and Innovation Policies

Assessing Canada's innovation environment

It is well beyond the scope of this essay to review the numerous assessments of factors influencing Canada's innovation performance that have been written over the years. The Council of Canadian Academics (2013) provides an overview of Canada's performance in science, technology, and innovation that is representative of much of this literature. One major conclusion of this overview is that Canadian academic research, overall, is strong and well regarded internationally. Their assessment is based primarily on the relative number of publications in peer-reviewed academic journals, citation rates to publications by Canadian authors, and survey responses of international scholars.[19]

A second conclusion is that research and development by Canadian businesses has been relatively weak, as measured by R&D spending as a share of Canada's gross domestic product. The study attributes the R&D spending gap in Canada to the decline in the manufacturing sector's share of the Canadian economy since 2001. Specifically, Canada's R&D gap relative to the US is attributed to the greater specialization of US manufacturing in higher technology and R&D-intensive industries than is the case for Canada.

A relatively recent government of Canada (2016) report highlights the relatively strong performance of Canada's investments in higher educa-

[19] In a more recent report, the Council of Canadian Academies (2018) qualifies this assessment somewhat. Specifically, it highlights lower than expected research output in the natural sciences and engineering areas that it considers particularly relevant for producing "strategic" technologies. Conversely, George-Cosh (2018, Feb. 8) highlights Canada's capabilities in artificial intelligence.

Table 1: Canada's Performance on Innovation Sub-indices, Relative to Leader

	Capacity for innovation	Quality of scientific research institutions	Company spending on R&D	University-industry collaboration in R&D	Government procurement of advanced technology products	Availability of scientists and engineers	PCT patents, applications/ million pop.*
2007-2008	0.787	0.919	0.738	0.875	0.774	0.950	
2008-2009	0.750	0.921	0.733	0.862	0.804	0.932	
2009-2010	0.746	0.919	0.700	0.881	0.857	0.917	
2010-2011	0.712	0.919	0.700	0.931	0.878	0.933	
2011-2012	0.707	0.889	0.695	0.897	0.854	0.900	
2012-2013	0.695	0.873	0.661	0.864	0.826	0.871	0.250
2013-2014	0.741	0.859	0.633	0.845	0.800	0.825	0.269
2014-2015	0.780	0.859	0.661	0.817	0.804	0.823	0.269
2015-2016	0.817	0.844	0.683	0.817	0.745	0.852	0.259
2016-2017	0.820	0.862	0.700	0.793	0.717	0.885	0.269
2017-2018	0.823	0.864	0.705	0.793	0.647	0.900	0.267
Average	0.761	0.884	0.692	0.852	0.791	0.890	0.264

Source: *Global Competitiveness Index* Historical Dataset 2007-2017, Version 20180226, World Economic Forum: http://reports.weforum.org/global-competitiveness-index-2017-2018/downloads/.

tion and in the quantity and quality of academic research. It also identifies a relative decline in business expenditures on research and development in Canada, as well as the small amount that Canadian firms invest in information and communications technologies compared to US firms. The report identifies a prominent gap between the relatively robust number of start-up companies in Canada and the failure of Canadian companies to grow beyond the start-up stage.

The Advisory Council on Economic Growth (2017) adds its support for the assessment that Canadian businesses struggle in the process of scaling up start-up companies. It also focuses attention on the declining priority of business R&D in Canada, while emphasizing the success of Canadian students in international tests of science, math, and reading abilities.

Information in the *Global Competitiveness Report* broadly confirms the general assessment of Canada's innovation environment outlined above in highlighting Canada's relatively weak performance in private sector R&D spending and in relatively weak translation of R&D spending

Table 2: Canada's Performance on Innovation Sub-indices, Relative to the United States

	Capacity for innovation	Quality of scientific research institutions	Company spending on R&D	University-industry collaboration in R&D	Government procurement of advanced technology products	Availability of scientists and engineers	PCT patents, applications/ million pop.*
2007-2008	0.889	0.934	0.776	0.875	0.837	1.018	
2008-2009	0.818	0.921	0.759	0.862	0.837	1.000	
2009-2010	0.800	0.919	0.750	0.881	0.875	0.982	
2010-2011	0.792	0.950	0.778	0.931	0.915	0.982	
2011-2012	0.788	0.966	0.774	0.912	0.872	0.982	
2012-2013	0.788	0.948	0.736	0.911	0.864	1.000	0.563
2013-2014	0.768	0.917	0.704	0.860	0.837	0.981	0.576
2014-2015	0.780	0.902	0.709	0.845	0.841	0.962	0.566
2015-2016	0.831	0.885	0.732	0.845	0.814	0.963	0.541
2016-2017	0.847	0.933	0.737	0.821	0.750	0.982	0.515
2017-2018	0.850	0.950	0.729	0.807	0.647	0.947	0.503
Average	0.814	0.930	0.744	0.868	0.826	0.982	0.544

Source: *Global Competitiveness Index* Historical Dataset 2007-2017, Version 20180226, World Economic Forum: http://reports.weforum.org/global-competitiveness-index-2017-2018/downloads/.

into commercial technology as measured by patenting activity. Tables 1 and 2 summarize Canada's performance on the innovation sub-pillars in the GCR described above. Specifically, table 1 reports the ratio of Canada's score on each of the seven sub-pillars relative to the score of the overall innovation leader in each period from 2007-2008 through 2017-2018, as well as the average over the full period. Table 2 reports the same ratios where the comparator country is the United States.

The data reported in table 1 suggest that Canada performs relatively well compared to the innovation leader on four of the innovation sub-pillars: quality of scientific research institutions, university-industry collaboration in R&D, government procurement of advanced technology parts, and availability of scientists and engineers. Canada performs relatively poorly in company spending on R&D and patents granted per million population, and somewhat better on capacity for innovation.[20]

[20] Capacity for innovation is defined as the extent to which companies have the

The data reported in table 2 reinforce the information in table 1 inasmuch as Canada's performance relative to the US is weakest in business spending on R&D and patents per million population. Since the US is not the innovation leader over the period 2011-2012 through 2017-2018, Canada's relative scores reported in table 2 tend to be higher than its relative scores reported in table 1, with government procurement of advanced technology parts being a notable exception.[21]

In summary, the information from the *Global Competitiveness Report's* innovation sub-pillars identifies the general weakness in private sector R&D performance, and particularly the apparent lack of success that Canadian businesses have in converting technological opportunities into successful technological outputs, as measured by relatively narrow attributes such as patents, or relatively broad measures such as international competitiveness. This outcome is notwithstanding the efforts of governments in Canada to promote commercially successful innovation through numerous government funding and tax incentive programs.[22]

Explaining and improving Canada's innovation performance

Canada's evident shortcomings in creating and commercializing new technology invite explanation. A number of possible justifications have been advanced over the years. As discussed earlier, the Council of Canadian Academies (2013) argues the relatively weak R&D performance of private sector firms in Canada, along with their limited innovation, reflects an industrial structure that is strongly tilted toward representation by firms engaged in natural resource extraction and primary manufacturing, as opposed to software, biotechnology, and other industries with greater technological opportunities. The council further asserts that since Canadian companies make "acceptable" profits (to shareholders) in low technology sectors, there is minimal pressure from capital markets for

capacity to innovate. The definition of patenting in the GCR changed after 2010-2011, which makes comparisons before and after that period suspect for the innovation sub-pillar. Hence, in tables 1 and 2, we report patent performance only starting in 2012-2013.

21 This sub-pillar measures the extent to which government purchasing decisions foster innovation.

22 Lester (2018) notes that just over half of subsidies to business from the federal and provincial governments in 2014-2015 were intended to encourage additional research and development and to enhance the ability of small firms to access external financing, including risk capital financing for innovation.

Canadian firms to move resources from sectors with limited innovation opportunities to those with more robust opportunities.

The council's argument fails to explain why Canadian firms can continue to make acceptable profits while failing to innovate given the importance of innovation to productivity growth. Canada is a relatively high wage country, and producers in the natural resource and primary manufacturing sectors in Canada face competition from producers in low-wage countries. A disinterest in innovating on the part of Canadian producers in these sectors should therefore lead to increasingly unacceptable profits over time.

The *Global Competitiveness Report* provides some evidence that is relevant to the robustness of the council's explanation of Canada's relatively poor innovation performance. Specifically, it identifies a sub-pillar that is part of the pillar identified as "Business Sophistication." This sub-pillar reflects survey respondents' answers to the following question: On what is the competitive advantage of your country's companies in international markets based? Respondents' answers could range from one for primarily low cost labour and natural resources to seven for primarily unique products and processes. For 2017-2018, Canada's reported value for this sub-pillar (4.1) was well below the value for Switzerland (6.5), which is identified as the innovation leader. Canada's value for this sub-pillar compares only somewhat less favourably to the 5.7 value reported for the United States. While fragmentary, this information does provide some support for an explanation of Canada's innovation performance that rests on a unique industrial structure for Canada. However, natural resource companies have been among the fastest growing in Canada in several past years, which highlights the fact that innovation is certainly possible in the natural resource sector.[23]

The government of Canada (2016) offers some additional possible explanations for Canada's innovation performance. In particular, it highlights problems that Canadian companies face in accessing venture capital.[24] Again, the *Global Competitiveness Report* provides some insight into the relevance of this explanation. A sub-pillar under the pillar entitled financial market development is based on survey responses to the following question: In your country, how easy is it for start-up entrepreneurs

[23] A discussion of whether and how resources should be transferred more quickly from Canadian resource sectors to Canadian technology-intensive sectors is beyond the scope of this report. It might also be added that simply growing the secondary manufacturing sector might not substantially improve innovation in Canada, as a number of technology oriented Canadian companies, including Nortel and Mitel, ultimately failed after enjoying initial success.

[24] The Council of Canadian Academies (2018) concludes that venture capital is readily available in Canada.

with innovative but risky projects to obtain equity financing? Canada's value for this sub-pillar (3.7) is somewhat below the 4.2 value for Switzerland but more substantially below the 5.2 value for the top-ranked United States.

Interestingly, Emes, Jackson and Globerman (2018) provide evidence showing that small business start-up rates in Canada in recent years compare favourably to small business start-up rates in the United States. This suggests that if venture capital financing is a significant barrier to innovation in Canada, the problem manifests in the "growth stage" of new businesses rather than in the start-up phase.

The government of Canada's (2017) Innovation and Skills Plan proposes to make available up to an additional $400 million through the Business Development Bank of Canada over three years for a new "venture capital catalyst" initiative that will increase late-stage venture capital available to Canadian entrepreneurs. Based on the evidence discussed above, it would seem reasonable to focus on later-stage financing;[25] however, Cumming and Johan (2018) provide evidence that Canadian Labour Sponsored Venture Capital Companies (CLSVCC) are relatively inefficient compared to privately financed venture capital companies.[26] Cumming and Johan also highlight the growth of private sources of risk capital, including crowdfunding. Compared to the United States, regulations in Canada have inhibited equity crowdfunding.

Some have suggested having government act as a limited partner in privately managed venture capital funds with payback rights subordinated to private institutional investors. This would effectively be an indirect tax credit with some of the adverse consequences of CLSVCCs. A possibly more effective strategy to promote late-stage venture financing might focus on reducing tax-based disincentives to risk capital by motivating more private sector risk-taking. We shall return to this point in the final section of this study.

The government of Canada's (2017) Innovation and Skills Plan also suggests other barriers to innovation in Canada. For example, the "Accelerating Innovation through Superclusters" in *Budget 2017* proposes to invest up to $950 million over 5 years to be provided on a competitive basis in support of a small number of business-led innovation superclusters. It will focus on highly innovative industries such as clean technology, advanced manufacturing, digital technology, health and biosciences, clean resources, agri-food, and transportation.

25 For some contrary evidence, see Howell (2017).

26 These are retail venture capital funds for which private investors benefit from tax incentives.

Information from the GRC provides some mixed evidence for a concern about cluster development. Specifically, the GRC reports scores for a sub-pillar category identified as the state of cluster development. The ratio of Canada's score to Switzerland's score is .902, while the ratio of Canada's score to the top-ranked US is .807. At the same time, Weller (2017) reports a ranking of the 25 most high-tech cities in the world as identified by the World Economic Forum. Canada has three cities ranked in the top 25: Toronto (9), Vancouver (14) and Montreal (18). This latter evidence does not suggest that weak clusters are a major source of Canada's innovation problem. Moreover, it is questionable whether government bureaucrats should be choosing the innovative industries to develop as superclusters.[27]

The Innovation and Skills Plan substantially boosts federal government financial support for labour market programs focused on education and training.[28] In particular, it expands eligibility for student grants for part-time students, as well as those with dependent children. It also provides funding to support work experience for Canadian students and to support organizations delivering digital skills training to students from kindergarten through grade 12.

While increased education and training for adults might improve their employment prospects, it is much less clear that it will promote innovation. To this point, the *Global Competitiveness Report* for 2017-2018 suggests that Canada is doing relatively well in comparison to innovation leaders when it comes to worker training. Specifically, a sub-pillar under the higher education and training pillar reports values for "local availability of specialized training services." Canada scores a 5.9 on this measure compared to 6.7 for Switzerland and 5.8 for the United States. Canada also scores relatively well in its quality of primary education. The *Global Competitiveness Report* gives Canada a score of 5.6 on this sub-pillar compared to a score of 6.2 for Switzerland and 5.5 for the United States.

Two other prescriptions for promoting innovation in Canada are worth mentioning. One is to put innovation at the forefront of government procurement by using government purchasing as a direct instrument to support Canadian firms engaged in R&D. A second is to reorient the National Research Council into collaborative sectoral centres that include business and government participants in order to encourage knowledge diffusion between business, academia, and government (Jenkins, 2017).

[27] Sá (2018) criticizes the Canadian government's supercluster initiative in part because of regional politics that are at work in the allocation of funding.

[28] The federal government's 2017 budget boosts federal support through the Labour Market Transfer Agreements by $2.7 billion over 6 years. See Canada (2017).

To the extent that government uses its purchasing activities as an instrument to promote innovation as opposed to acting as an efficient producer of public goods, the purchasing instrument is simply an indirect financial subsidy. Indeed, it is a particularly undesirable form of financial subsidy, since it is less transparent than direct subsidies. Innovative Canadian companies enjoy a potentially large international market in which they can sell their products, so that larger or smaller purchases by government buyers should not be critical determinants of whether Canadian start-up companies will be able to gain larger scale through commercially successful sales.

In any case, over the period 2011-2012 to 2017-2018, Canada scores relatively well on the sub-pillar identifying government procurement of innovative products compared to the innovation leader, as shown by the ratios reported in column 5 of table 1. Furthermore, while reorganizing the National Research Council might encourage a more efficient exchange of knowledge between business and academia, barriers to collaborative innovation between the two sectors does not seem to be a significant factor contributing to Canada's innovation performance. This is shown by the close approximation between Canada's index values for university–industry collaboration and those of the innovation leader (table 1, column 4), as well as those of the US (table 2, column 4).

In summary, the available evidence suggests that the weak link in Canada's innovation process is the limited success that start-up companies have in using new technologies to become anchor firms in a growing innovation ecosystem. The evidence also supports the conclusion that the many government initiatives to promote innovation in Canada over decades have been unsuccessful. Indeed, Canada's innovation performance in recent years has, if anything, deteriorated relative to leading countries. The federal government's new Innovation and Skills Plan continues the broad approach of promoting innovation through government-funding programs, albeit with more emphasis than earlier programs on later-stage venture capital financing and cluster development.

6. Concluding Comments

Well recognized, multi-variate measures suggest that relative to leading developed countries, Canada's innovation performance has deteriorated in recent years, and that this phenomenon has contributed to weaker international competitiveness of the Canadian economy. Since relatively weak innovation has been a preoccupation of Canadian governments for multiple decades, Canada's recent innovation experience is discouraging news.

A recent Statistics Canada (2018 b) study reports that Canadian businesses became more innovative over the period 2015-2017 compared to earlier years, which is a seeming contradiction to our findings. Specifically, a larger percentage of sampled companies compared to 2009 and 2012 reported implementing a new or significantly improved product or process, or a new marketing or organizational method. This measure of innovation obviously differs substantially from the league table measures that we rely upon. In particular, our measures compare Canada's innovation performance to those of other countries rather than focusing on Canada's absolute performance. Furthermore, Statistics Canada's measure of innovation is a relatively weak standard as suggested by the fact that almost 80 percent of the companies sampled were categorized as "innovative enterprises" for the period 2015-2017.

In the event, available information and data suggest that Canada's relatively weak innovation performance is linked not so much to weak business start-up activity, but rather to a seeming lack of success of incumbent companies to be innovative leaders. Canadian governments have tried to promote increased R&D and innovation over decades through various direct and indirect funding programs.[29] Whatever the theoretical arguments for and against the economic logic of such government funding, Canada's relatively weak innovation performance has apparently not been remedied.

Obviously, there is no simple prescription to promote successful innovation by incumbent companies. However, there are arguably policy in-

[29] For an extensive discussion of R&D tax incentives in Canada and a comparison to the tax incentives in other OECD countries, see OECD (2018). As recently as 2014, tax incentives accounted for about 80 percent of federal government innovation spending.

itiatives that Canadian governments might pursue more aggressively that would enhance private-sector incentives to innovate. One such initiative is to increase competition in domestic industries, specifically by eliminating regulations that limit or discourage foreign-owned companies from competing in Canada. This is particularly relevant in the case of industries that provide critical infrastructure, such as telecommunications and transportation, as well as those providing financial capital, notably commercial banking.

The Council of Canadian Academies (2013) and others have remarked upon the poor culture of innovation in Canadian companies. Some argue that the poor culture reflects satisfaction with the status quo. Others suggest a lack of managerial expertise and competence. In either case, more direct and indirect competition would be salutary. As noted above, eliminating foreign ownership restrictions would provide for increased direct competition.[30] Increasing the number of highly educated immigrants allowed into Canada, particularly those with advanced training in science and engineering, would provide indirect competition for incumbent managers and owners of domestic business.

Once again, data reported in the *Global Competitiveness Report* (2017-2018) is relevant. One sub-pillar reports the aggregate responses to a question about the concentration of corporate activity. Specifically, respondents choose a value on a seven-point scale, where unity denotes that a few business groups dominate domestic industries and seven denotes that corporate activity is spread among many firms. On this sub-pillar, Canada (ranked 24) is well below Switzerland (ranked 1) and the US (ranked 3).[31]

More generally, the GCR identifies government regulation as a relatively strong factor depressing Canada's competitiveness. For a sub-pillar identifying the burden of government regulation, Canada ranks 38th of all countries in the sample compared to Switzerland (which is ranked 6th) and to the US (ranked 12th). Canada's numerical value on this sub-pillar relative to the value for Switzerland equals .792, which is close to Canada's value relative to that of the US (.809).

Canada's tax structure might also be contributing to its relatively poor economic performance. The GCR identifies a weak Canadian performance on the sub-pillar "effect of taxation on incentives to invest." Specifically, Canada ranks 49th on this metric, while Switzerland ranks 6th,

[30] For empirical evidence that inward foreign direct investment promotes increased efficiency in Canadian-owned manufacturing companies, see Globerman (1979).

[31] The ratio of Canada's sub-pillar value relative to Switzerland's is .746. The ratio of Canada's value to that of the US is .800.

and the US ranks 18th. Canada's value for this sub-pillar relative to Switzerland's value equals .722.[32] The precise features of the tax systems that matter to investment are not identified in the relevant sub-pillar. However, in the comparison of Canada to Switzerland, the relevant feature might well be the fact that Switzerland has no capital gains tax, while Canada's top marginal tax rate on capital gains is above the average of all developed countries in the OECD.[33]

Cumming and Johan (2018) conclude that low capital gains taxes are critical to a large and vibrant venture capital market, and that government subsidy programs are not as efficient as tax programs that create incentives for, and reward, effort.[34] In a similar vein, Brown, Fazzari, and Petersen (2009) provide evidence that business tax policies are an important instrument affecting R&D investment and innovation. This is especially true given the importance of equity as the primary instrument to finance innovation.

There are, of course, other differences between Canada and the innovation leaders that may be indirectly related to Canada's relative innovation performance. This study makes no claim to offer a comprehensive set of policy prescriptions to improve innovation in Canada.[35] It does raise strong grounds for skepticism about whether the government of Canada's Innovation and Skills Plan will be more effective than other "top-down" innovation-promotion government initiatives that have been tried in the past.

While the establishment of Innovation Canada, as proposed in the 2017 federal government budget, is meant to consolidate different innovation programs situated across many government departments, Watson (2018) notes that there will still be 35 or more innovation programs at the federal level. Provincial and municipal governments also have their own innovation programs. Watson further notes that if government innovation programs were a solution, Canada's innovation problems would have been solved long ago.

[32] Canada's value relative to that of the US is .830.

[33] For recent estimates of capital gains tax rates, see Mitchell, Garst, Lammam, and Jackson (2018). Note that the top capital gains tax rate in Canada is actually below that of the United States.

[34] They also discuss the relevance of bankruptcy laws and their influence on entrepreneurship.

[35] Cumming and Johan (2018) discuss a range of other policies from entrepreneur friendly bankruptcy laws to security laws that promote initial public offerings and that enable financial intermediaries to scale up investments.

In this context, the establishment of yet another high-level government department continues an unsuccessful top-down approach to improving Canada's innovation performance.

Appendix A: Canada's Performance

Appendix Table 1: Canada's Performance on the *Global Competitiveness Index*, Relative to the Global Leader and the United States

	Canada's rank (all countries)	Canada's score relative to leader	Canada's score relative to U.S.	Canada's rank (OECD only)
2007-2008	13	0.930	0.930	11
2008-2009	10	0.947	0.947	7
2009-2010	9	0.946	0.946	8
2010-2011	10	0.946	0.981	7
2011-2012	12	0.930	0.981	10
2012-2013	14	0.930	0.964	9
2013-2014	14	0.912	0.945	10
2014-2015	15	0.912	0.945	11
2015-2016	13	0.914	0.946	10
2016-2017	15	0.914	0.930	11
2017-2018	14	0.898	0.898	12

Source: *Global Competitiveness Index* Historical Dataset 2007-2017, ersion 20180226ersion 20180226, World Economic Forum: http://reports.weforum.org/global-competitiveness-index-2017-2018/downloads/

Appendix Table 2: Canada's Performance on the innovation Pillar of the *Global Competitiveness Index*, Relative to the Global Leader and the United States

	Canada's rank (all countries)	Canada's score relative to leader	Canada's score relative to U.S.	Canada's rank (OECD only)
2007-2008	13	0.845	0.845	10
2008-2009	13	0.828	0.828	10
2009-2010	12	0.828	0.828	9
2010-2011	11	0.860	0.860	8
2011-2012	11	0.879	0.911	8
2012-2013	22	0.793	0.836	19
2013-2014	21	0.776	0.833	18
2014-2015	22	0.776	0.818	18
2015-2016	22	0.793	0.821	18
2016-2017	24	0.793	0.821	19
2017-2018	23	0.810	0.810	17

Source: *Global Competitiveness Index* Historical Dataset 2007-2017, ersion 20180226ersion 20180226, World Economic Forum: http://reports.weforum.org/global-competitiveness-index-2017-2018/downloads/

Appendix Table 3: Canada's Performance on the *Global Innovation Index*, Relative to the Global Leader and the United States

	Canada's rank (all countries)	Canada's score relative to leader	Canada's score relative to U.S.	Canada's rank (OECD only)
2011	8	0.882	0.995	6
2012	12	0.834	0.986	10
2013	11	0.865	0.955	9
2014	12	0.866	0.933	10
2015	16	0.816	0.927	14
2016	15	0.825	0.891	13
2017	18	0.793	0.875	16
2018	18	0.775	0.886	15

Source: Global Innovation Index (2011 through 2018 reports): https://www.globalinnovationindex.org/home

Appendix B: List of Countries used in Correlation Analysis

- Switzerland
- Canada
- Netherlands
- Norway
- Sweden
- Australia
- United Kingdom
- Austria
- Singapore
- New Zealand
- United States
- Iceland
- Finland
- Estonia
- Denmark
- Belgium
- Germany
- Malta
- Ireland
- Czech Republic
- Israel
- Spain
- Korea
- Cyprus
- Japan
- Slovenia
- Hong Kong
- Italy
- Luxembourg
- France
- China

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