CANADIAN AMERICAN BUSINESS COUNCIL

CABC Policy Recommendations to Enhance Innovation in Canada

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Contents

Executive Summary

The Canadian American Business Council is pleased to offer the following recommendations for consideration by the Government of Canada to advance its innovation agenda and help grow the economy of North America.

The recommendations that follow are designed to be achievable and affordable within the next three to five years, without requiring additional public expenditures beyond what has been outlined in the federal budget.

While the Canadian economy enjoys sound fundamentals and many advantages, Canada currently has a widely recognized "innovation problem" which the government and multiple stakeholders, including CABC, are committed to addressing. Canada has slipped in the World Economic Forum's Global Competiveness Ranking, falling from 11th to 22nd place in one year. The Conference Board ranks Canada 13 out of 16 in innovation and investment in R&D compared to its peers.

The good news is that the Government of Canada is committed to addressing innovation impediments, and CABC has specific actionable recommendations that could help substantially. This paper outlines in detail our policy suggestions which include:

- Strengthening links between Canada's science base and industry;
- Reforming the legal framework for innovation including the patent system; and
- Improving the access of innovative small and start-up firms to risk capital; and to make capital available for early stage commercialization of innovation.

Enhancing Canadian innovation is a North American imperative. Under NAFTA, Canada, the United States and Mexico are moving toward a single integrated economy, a trend that is most pronounced and observable in technology-intensive sectors like aerospace, electronics, precision instruments and automotive products, dynamic industries which contribute more to economic growth than their output and employment figures alone would suggest. All three countries share a growing stake in how these and other high tech sectors perform in international competition. Because North American industries cannot seek to compete globally on the basis of low labor costs, they must pursue knowledge-based competitive strategies. North America's integrated high technology industries will remain competitive globally to the extent they can innovate -- applying the best trained and best educated human capital to drive the systematic application of new technologies in the commercial realm. For North America to succeed, the innovation potential of each country, each state and each province must be fully realized. A more innovative Canada will directly benefit all of North America.

Our conclusion is that it is in our interests in the US and Canada to take every possible step to encourage economic growth and prosperity. We recommend that Canada leverage its strong fundamentals to improve its innovation ecosystem to be fully competitive with peer countries in order to enhance continental competitiveness in the years ahead.

I. Introduction

The Trudeau government won its election based in part on a pledge to spur Canada's economic growth through a strategy based on innovation. The need to do so is vitally important. The platform set forth several specific steps to achieve this objective:

> *We will kick-start investment in innovation to grow our economy and create good, middle class jobs. To get our economy growing again, we need to immediately invest in helping our businesses and entrepreneurs – including those in manu-facturing – become more innovative, competitive, and successful. Over the next three years, we will:*
>
> • *Invest $200 million each year in a new Innovation Agenda to significantly expand support for incubators and accelerators, as well as the emerging national network for business innovation and cluster support; and*
>
> • *Invest an additional $100 million each year in the Industrial Research Assistance Program, which has a proven track record of helping small- and medium-sized businesses to innovate and become world leaders.*[1]

The first budget of the Trudeau government recently provided a comprehensive plan to deliver on the promises made, with a major emphasis on a series of measures to foster innovation. The Budget pro-vides the following overview:

> *In Budget 2016 the Government is defining a new vision for Canada's economy: to build Canada as a centre of global innovation. Canada will be propelled by its creative and entrepreneurial citizens; its leading science and technology; its ex-cellent innovation infrastructure; and its globally competitive companies offering high-quality products and services, thriving within a business environment that supports commercialization and growth. Through 2016 and 2017, the Government will define a bold new plan, its Innovation Agenda, to achieve this vision.*
>
> *Through 2016, the Government will redesign and redefine how it supports innova-tion and growth, in partnership and coordination with the private sector, provinces, territories and municipalities, universities and colleges, and the not-for-profit sector.*
>
> *The Innovation Agenda will define clear outcomes – objectives and metrics to mea-sure progress towards this vision.*
>
> *The Government's plan will be cross-government and coordinated across key departments. Whether it is clean technology, health sciences, advanced manufac-turing, digital technology, resource development or agri-food, the Government's*

plan will work to align its support for the key ingredients of innovation – helping to propel Canada's entrepreneurs and innovators from start-up and commercialization stages to global success.

Budget 2016 invests in infrastructure at post-secondary institutions through a new Post-Secondary Institutions Strategic Investment Fund, increases funding to three national Research Councils, invests further in Genome Canada, the Centre for Drug Research and Development, the Perimeter Institute for Theoretical Physics and the Brain Canada Foundation. Funds amounting to $800 million over four years are to allocated to clusters and innovation networks. Accelerators and incubators are to be the subject of a new metric, developed with stakeholders, to benchmark their performance. In short, innovation has been given a high profile place in the first new Trudeau administration budget.

The purpose of this paper is to offer some specific recommendations for consideration as part of this major new thrust of Canadian policy, largely based on successful approaches taken by Canada's peer countries, which are doable, affordable, and with the clear potential for delivering the needed positive impact in the next three years. These additional measures can be taken over the near term. They do not have to entail further large public expenditures to stimulate innovation, investment and economic growth. The emphasis in this paper is to avoid adding to the projected Federal budget deficits by studying best practices abroad and adapting what is learned to the Canadian innovation ecosystem, by re-purposing existing programs, by innovations and legal reforms in the area of intellectual prop-erty protection, and by promoting a culture of innovation in Canada. They can be part of the powerful reforms that are within reach to strengthen Canada's international competitiveness.

II. Defining the Challenge

The Trudeau government acknowledges the challenges and opportunities Canada faces in an era of globalization, rapid technological change, intensifying competition, an aging population and income inequality. As recent economic trends have underscored, the country cannot rely on its natural resource endowments to sustain its standard of living over the long term. The path to a secure and prosperous future lies through innovation and the associated leaps in labor productivity which innovation enables. Canada has a rich heritage of innovation and it is a world leader in many of the factors which underlie successful innovation. However, numerous objective indicators suggest that Canada lags its peer coun-tries in innovation itself and in a number of the key factors which make innovation possible. The govern-ment acknowledges this challenge:

> *A Liberal government would provide hundreds of millions in new money to help support the country's startup and innovation sectors, party leader Justin Trudeau said Tuesday, saying that Canada has "fallen behind" in developing new technolo-gies for use around the world.*[6]

For a number of years the Conference Board of Canada has monitored Canada's relative performance in the Global Innovation Index and drawn conclusions about implications for the country. Most recently Canada ranked 16th among countries on the Global Innovation Index.[7] This can be seen as being rea-sonably good in a field of 141 economies, but as the Conference Board of Canada observed:

> *Despite a decade or so of innovation agendas and prosperity reports, Canada remains near the bottom of its peer group on innovation, ranking 13th among the 16 peer countries. Countries that are more innovative are passing Canada on mea-sures such as income per capita, productivity, and the quality of social programs.*[8]

The Conference Board published a grading system based on a series of international rankings. Using this system, the Conference Board accorded Canada not a single "A" grade, but a reasonable number of "B"s – good but not excellent:

- Number and ease of creating new companies (2nd of 15 peer countries)
- Number of scientific articles (8th of 16)
- Online provision of government services (4th of 16)
- Public R&D spending (8th of 16)
- Numbers of citations of scientific papers (5th of 10)
- Low regulatory barriers to entrepreneurship (4th of 160)

Canada did less well, and was given a "C" grade in two categories:

- Knowledge-intensive services (11th of 16)
- Export market share – Aerospace (4th of 16)

Canada was given a grade of "D" in too many categories:

- Export market share – pharmaceuticals – (14th of 16)

- Patents relative to size of economy – (14th of 16)
- Patents relative to population – (14th of 16)
- Protection of trademarks – (15th of 15)
- Business expenditures on R&D – 15th of 16)
- More advanced levels of manufacturing – (13th of 16)
- Exports of electronics, computers – (12th of 16)
- Exports of instruments – (14th of 16)
- ICT investment – (8th of 15)
- Venture capital availability as % of GDP – (14th of 16)
- Patenting firms < 5 years since founding – (13th of 15), and
- Connectivity – (14th of 16).

The shortcomings highlighted by the Conference Board are a concern for policymakers seeking to leverage innovation to restore the country's economic growth. It is telling that in its annual survey of CEOs who were asked to list the 50 most innovative firms in the world, not one of those cited is head-quartered in Canada.[11] This state of affairs cries out for change, and fortunately the means are at hand to deliver that change.

a. the current economic stagnation despite sound fundamentals

The factors underlying Canada's recent economic performance were vigorously debated in the recent election, but the weakness of that performance itself was largely undisputed.[12] Canada's economy shrank in each of the first two calendar quarters of 2015 – technically a recession – reflecting among other factors, declining commodity prices and growth was anemic through the 4th quarter.[13] Unem-ployment edged up to 7.1 percent in December 2015 from 7.0 percent in August – the highest level since February 2014,[14] and hit 7.3% in February, 2016.[15] In October 2015, the International Monetary Fund modified its growth forecast for the Canadian economy from 1.5 percent (a figure used in July) to 1.0 percent, and reduced its growth forecast for 2016 from 2.1 percent to 1.7 percent.[16]

Despite the current economic sluggishness, many of Canada's economic fundamentals are not only sound, but exemplary. The 2015 Global Competitiveness Index compiled annually by the World Eco-nomic Forum ranked Canada 4th among 141 countries in financial market development, 7th in the health and primary education, 7th in labor market efficiency. Its natural resource endowments are well known and the Toronto Stock Exchange is one of the world's leading centers for raising capital for natural resource development. Canada ranks higher than its G-7 peers with respect to public sector integrity, ranking 10th in Transparency International's most recent report on 175 countries (the U.S. is 17th). Canada enjoys one of the world's most open-door immigration policies and has a strong record of integrating immigrants into its society.

Depressed commodities prices offer a partial and short-term explanation for Canada's economic per-for-mance but should not mask longer term trends that have been noted with concern by Canadian gov-ern-ment, business and academic leaders. The 2011 "Jenkins Report," Innovation Canada: A Call to Action, observed that short-term factors, such as higher resource prices, may lift economic activity for a time, but ultimately "it is labor productivity growth that drives increases in average per capita incomes and busi-ness competitiveness." The report observed that:

Productivity growth, in turn, is primarily the result of innovation.[17]

b. Canada has a widely recognized innovation problem.

The shortfall in Canada's performance in terms of innovation has been the subject of numerous studies and public commentary for over a decade. In September 2012 the Conference Board of Canada re-leased Who Dimmed the Lights? Canada's Declining Global Competitiveness Ranking, which noted the country's slippage in the World Economic Forum Global Competitiveness Index – a trend which has continued.[18] "Countries that are more innovative are passing Canada on measures such as income per capita, productivity, and the quality of social programs."[19] The Board noted that "particularly" severe was the drop in ranking in the category "innovation indicators," where Canada fell a worrying 11 places—from 11th to 22nd—in one year. "This is especially disappointing, given that Canada is an advanced economy and at a stage of development and future prosperity rests mostly on its capacity to innovate." Daniel Muzyka, President and CEO of the Conference Board, concluded that:

Too often, Canada fails to commercialize its good ideas into marketable products and services or capture the value from growth.[21]

At present, with respect to innovation, the Conference Board ranks Canada 13th out of 16 advanced countries regarded as its peers.

As other countries innovate and invest in research and development, Canada has fallen behind. According to the World Economic Forum, Canada now places 22nd in a global ranking on innovation, down from 12th in 2009.[22]

The Conference Board's conclusions are consistent with other Canadian surveys and studies of the state of innovation in Canada. In a 2011 report by a Canadian Experts Panel on Federal Support for R&D in Canada (the "Jenkins Report") the authors declared that "Canada has a business innovation problem" manifested in "Canada's subpar productivity growth," which averaged a "mere" 0.6 percent over the 2000-2009 period, or less than half the average of 1.5 percent for OECD countries.[23] The Experts Panel observed that with respect to business expenditures on R&D (BERD), based on a comparison with 30 countries regarded as comparable in terms of size and level of development, Canada was at the bottom of the third quartile. Canada's BERD intensity of 1 percent of GDP was well below the OECD average of 1.6 percent and had been declining steadily since the tech boom's peak in 2001.[24]

The Expert Panel on the State of Industrial R&D in Canada ranked Canada at 11th of the top 20 in terms of business spending on R&D. The share of GDP expended for this purpose by Canada was .89% com-pared with 2.8% for Korea, 2.49% for Japan, 2.08% for Chinese Taipei, 1.9% for Germany and 1.89% for the United States. Noteworthy among the Panel's findings is that "Fewer large firms undertake I[Indus-trial] R&D in Canada than in highly IR&D-intensive countries" and that "the share of total IR&D performed by smaller companies has increased." This paper will revert to that fact later in this paper. Perhaps not surprisingly, the Expert Panel found that, based on average annual growth in labour productivity for OECD countries was 1.5 percent for 2000–2011, and 0.9 percent for Canada.

A 2009 study of Canadian business innovation by the Council of Canadian Academies concluded that Canada suffered from a "deeply-rooted innovation conundrum (p. 12) which was responsible for "a serious productivity growth problem" (p. 11); that Canadian business had "a mediocre innovation re-cord (p. 10); and that the commercialization of Canadian university-based research "on the whole, dis-appointing (p. 8)."[26]

c. The Shortfall in R&D spending.

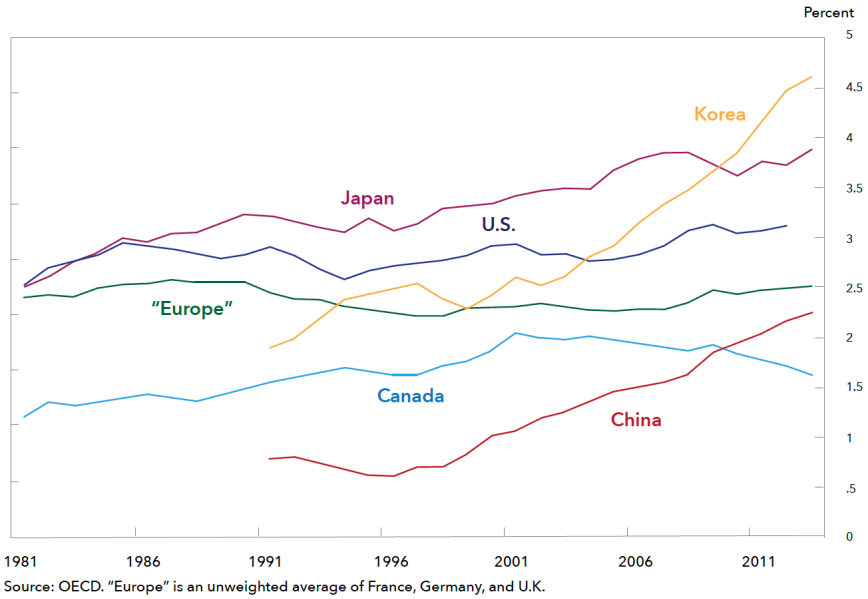
In 2015, The Toronto Star reported that in its latest report on science and technology performance, the OECD found that:

> *Canada's R&D spending as a percentage of GDP ranked a miserable 21st [out of 34]. Chronic business underinvestment in R&D – at 0.88 percent of GDP it is out-ranked by most OECD countries – helps account for Canada's chronically low rate of productivity growth.*[27]

Looked at graphically, the comparison is even more stark.

R&D Expenditures

As a percent of GDP



Source: OECD. "Europe" is an unweighted average of France, Germany, and U.K.

From 2001, Canada's R&D expenditures have been on a downward slope. This performance is a dra-matic outlier when compared to that of Japan, the United States, China, Korea, and even a combination of leading European countries – France, Germany and the United Kingdom. Likely linked to the shortfall in R&D spending is a decline in productivity. The 2010 report, An Action Plan for Prosperity, produced

by the Innovation Coalition for Action on Innovation in Canada noted that the annual rate of productivity increase in Canada was a low 0.7%, short of its own record in the prior two decades and lower than that of the United States.[29]

The pharmaceutical industry is particularly important in any assessment of Canada's innovation per-formance because globally pharmaceuticals are the most research-intensive sector, investing over $135 billion annually in drug discovery, development and commercialization. Annual pharmaceutical R&D spending is five times greater than that of the aerospace-defense industries, 4.5 times that of the chemical industry and 2.5 times that of the computer and software services industry.[30] Within Canada, 20 pharmaceuti-cal companies were among the country's top 100 R&D spenders in 2013. Pharmaceuti-cals account for about 10 percent of all Canadian business R&D and a quarter of its venture capital.[31]
A 2009 Council of Canadian Academies study found that massive increases in public and private R&D spend-ing on pharmaceuticals in Canada between 1988 and 2003 appeared to have had little if any commercial impact. Pharmaceuticals' share of Canada's business GDP stagnated at about 0.5 percent, in contrast to the United States, where pharmaceuticals' share nearly doubled, from 0.6 percent of busi-ness GDP in 1987 to 1 percent in 2002. The study concluded that:

> *[A]lthough Canada has a policy to promote pharmaceutical R&D spending in Canada, and has had success in doing so, the domestic competitive impact has been limited. Even in areas where Canadian research has been successful, the ex-ploitation of that knowledge has tended to take place elsewhere.*[33]

A 2010 study of federal R&D spending by Canada's Research-Based Pharmaceutical Companies ob-served that employment in the domestic pharmaceutical industry had declined by 28 percent in the pre-ceding de-cade and there had been an 18 percent decrease in the number of new patented medicines introduced each year. One important structural factor cited by the study as underlying these trends was that "Canada's IP re-gime provides less effective protection to innovators than those available in other advanced economies."[34]
For Canada, R&D has been strongest in the oil and gas sectors, strong in information technology, and weaker in communications and declining in pharmaceuticals.[35]

d. Canada's lagging performance in patent applications.

The Global Innovation Index, in which Canada ranked 16th in 2015, is derived from dozens of sub-in-dices of factors underlying innovation in thematic areas such as business sophistication, infrastructure, knowledge and technology outputs, and creative outputs. In the two categories related to domestic patent applications, Canada ranked substantially lower than 16th, meaning that its underperformance in patent-related indices pulls down its overall ranking.

Index	Canada Rank
Domestic resident patent application	32
Resident patent application	24

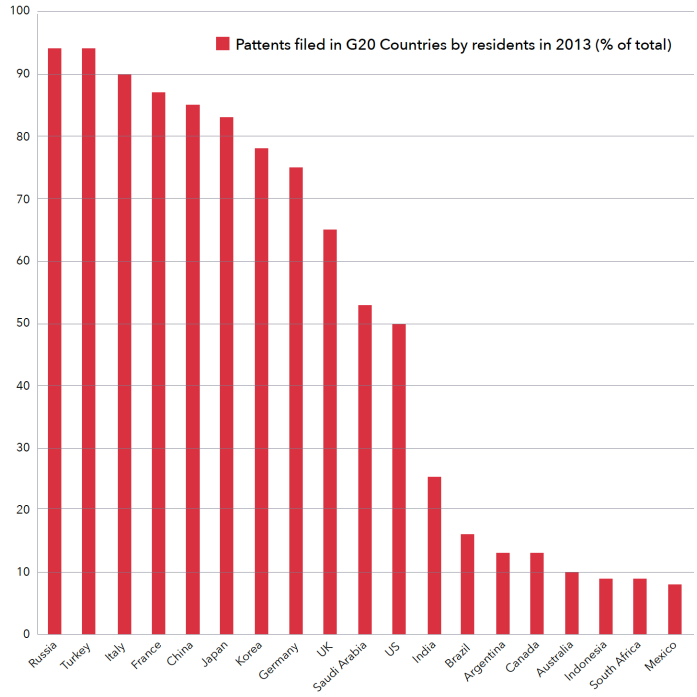
These several recent rankings of patenting place Canada near the bottom of its peer countries.[36] Patent applications, which measure outputs of the research process rather than inputs like R&D spending, are regarded as an important indicator of innovation. A 2014 study by the Toronto-based re-search organization C.D. Howe Institute surveyed a database of over 1 million patent applications to the Canada Intellectual Property Office (CIPO) for the period 1980 to 2013. Overall, C.D. Howe concluded that "all provinces have seen a fall in patent application rates in the past decade," and Canada "appears to be struggling with the commercialization aspect of the innovation process."[37] The study identified one sector that was particularly a weak performer with respect to patent applications, pharmaceuticals and medical devices:

> *[T]he pharmaceuticals and medical equipment sector has a low share of Canadian investors applying for patents for the Canadian market. . . . [T]he patent-reliant pharmaceutical and medical devices manufacturing sector shows a relatively weak Canadian presence. . . . In the pharmaceutical and medical device sector, Canadian investors looking to patent in Canada are few and far between.*[38]

One chart tends to tell the story. The World Bank shows Canada lagging badly in terms of the pat-ents that its own residents file in Canada as compared with those filed in other countries by resi-dents of those countries.

R&D Expenditures

As a percent of GDP



III. What Solutions Are Needed?

The new government has pledged to step up public financial support for innovation as a centerpiece of its economic program and Budget 2016 provides concrete follow-through. While the government's commitment of increased resources will certainly have a positive impact, not every support measure re-quires a major budget outlay or, for that matter, will take many years to have discernible positive effects. As peer countries have demonstrated, adjustments to institutional and legal structures and clarification of the mission of existing organizations involving relatively modest or even minimal public outlays also hold out potential to stimulate domestic innovation in the near term.

Peer countries grappling with the challenges of innovation commonly study the best practices of what they regard as highly innovative competitor countries as a predicate for the adoption of new mea-sures. A salient recent example was the Hauser Report commissioned in 2009 by the UK's then-Labor government which formed the basis for the reorganization of Britain's applied research infrastructure following study of research intermediary organizations in the peer countries, most notably Germany.[39] Similarly in 2006, France launched its Carnot Initiative, repurposing numerous public research organiza-tions along the lines of Germany's Fraunhofer-Gesellschaft to connect French basic science with French industry. Numerous countries have adjusted their patent policies based on the recent experience of the United States. [40]

The Committee on Comparative National Innovation Policies of the National Academies in the United States conducted a multi-year study of other countries' experiences, producing a series of recommenda-tions to improve the U.S. innovation ecosystem. The Report published in 2012 by the National Research Council, entitled Rising to the Challenge: U.S. Innovation Policy for the Global Economy, provided case studies of Germany, Flanders, Finland, Canada and Japan.[41] The Committee was made up of a cross-sec-tion of specialists in international competition among industries. It had published separately a series of country reports. Relevant standing bodies in the United States include the President's Committee on Science and Technology (PCAST) and the Science, Technology and Economic Policy (STEP) Board of the National Academies. In Germany, the Commission of Experts for the Research and Innovation (EFI) completed a series of reports for the German government. The Commission was independent from the German government and free to choose its own topics.[42] Canada itself has occasionally studied foreign best practices in innovation, but another such review would be beneficial, not only because peer country practices are evolving, but in order to focus in particular on certain foreign measures of immediate rele-vance to Canada today.

Peer country reforms in innovation typically do not entail massive new public expenditures or the whole-sale overhaul of the research infrastructure, but targeted measures to remove legal and institutional impediments to innovation and to break down silos between the research base and industry. Canada already has a rich endowment of the prerequisites for innovation, ranging from entrepreneurialism to world-leading government and financial institutions. The question is, based on peer country experience, what comparable measures might be taken over the short run, largely based on existing resources, to unleash Canadian innovation? Given strong emphasis on innovation in the Trudeau Budget for 2016, it would appear that the current government would be very receptive to whatever policy improvements might be added to the extensive list of initiatives that are currently planned. In the case of Canada, given a need to enhance the culture of innovation, interaction among executives of small, medium and large businesses, educators, academicians, and former government officials, focused on how to foster interaction among the constituencies they represent should hold substantial promise.

Based the challenges outlined above and peer country experience, the following recommendations should be considered by the new government:

- *Strengthen the links between Canada's science base and industry by reinforcing existing and creating new public research intermediary institutions and programs:*

  - In the context of the Canadian government's intention to expand national networks for business innovation and cluster support, the National Re-search Council should designate specific existing thematic research insti-tutes with the mission of serving as bridges between Canada's research universities and basic research organizations, on the one hand, and Cana-dian industry, on the other hand, to facilitate development of commercial-ly-relevant products and industrial processes.

  - Budget 2016 increases IRAP's resources to make its services more broadly available to a larger percentage of Canada's small businesses.

- *Reform the legal framework for innovation, including the patent system, to encourage rather than deter innovation, based on best practices of Can-ada's peer countries.*

  - Serious consideration should be given to enactment of legislation that would clarify on a uniform basis the extent to which recipients of govern-ment research grants and contracts, such as universities, can patent and exploit their discoveries.

  - The "Promise Doctrine" should be eliminated from Canadian patent jurisprudence by Parliamentary action which clarifies the patent law.

- *Improve the access of innovative small and start-up firms to risk capital to make capital available for early stage commercialization of innovations. giving con-sideration to measures such as use of public pension assets to support innova-tion, tax incentives for venture capital investments, and new programs. Foreign best practices such as the U.S. SBIR program and Taiwan's measures to sup-port venture investment should be studied with an eye to creating comparable structures in Canada.*

- *Enhance support for clean tech innovation. Canada's advantages (huge re-newables resources, know-how developed by Canadian energy companies) should be exploited by expanding the domestic innovation infrastructure with the objective of making Canada a world leader in renewable energy tech-nology and manufacturing.*

Taking each of these recommendations in turn:

(1) Reaffirming Canada's commitment to basic research.

In recent years, the Canadian government took a series of policy measures which reduced the priority of basic research in favor of commercially-relevant applied research. This change was heavily criticized by some elements of the Canadian science community. [43]

National Research Council. The National Research Council (NRC), the federal government's premier research organization, operates numerous research institutes and programs and can cite achievements such as the development of canola, the airline "black box," and a vaccine for meningitis. The 2011 Jen-kins Report observed that the NRC's mandate was "overly broad – and therefore unfocused and frag-mented."[44] In 2013 the Canadian Federal government declared that the NRC had become "a loose web of individual fiefdoms, each pursuing its own goals" and had "wandered" from its traditional role as developer of technology for industry into basic research "that may not have obvious business applica-tions."[45] The government transformed the NRC from an entity "formerly focused on basic research" into a one-stop "concierge service to bolster technology innovation by industry."

Critics charged that the reorientation of the NRC – one manifestation of the government's prioritization of applied over basic research – harmed Canada where it was strongest, in basic science, and could result in a brain drain of eminent scientists. According to an NRC employees' group represented by the Professional Institute of the Public Service of Canada, cuts in the NRC's research staff ended "world class research in the fields of plant metabolism and molecular biochemistry and ecotoxicology. A PIPSC spokesperson commented that:

> *This announcement is just another example of the government's complete lack of interest in science and fundamental research. While it maintains that it is in favor of "useful" research, it doesn't hesitate to slash away again and again at our coun-try's scientific infrastructure. The NRC is a key player supporting Canada's interna-tional competitiveness, but. . . . This once proud institution is fast becoming a shell of its former self.*[48]

Innovation requires both the scientific discoveries that arise from basic research as well as the ability to transform those discoveries into useful products and processes through applied research. Basic and applied research have always been interrelated and are becoming more so at present.[49] Institutional in-stability, including the most recent reorientation of the NRC, may damage or destroy Canadian research capabilities that are crucial to the country's future. The prior government's view was that universities are better positioned to pursue basic research than public research organizations such as the NRC institutes, but international experience suggests that in addition to university-based research, non-academic public research institutions are important contributors to innovation. The new government needs to reverse the prior government's course and reaffirm Canada's commitment to basic scientific research, with an eye to halting further "brain drain". The NRC's institutes should be restructured as autonomous research entities and in each case given a clear mandate to pursue either basic research or bridging the gap be-tween the research base and industry (see below) thus establishing both a clear delineation and struc-tures fostering collaboration between research communities similar to that found in Germany between Max Planck Gesellschaft (basic) and the Fraunhofer Gesellschaft (applied).

Innovation culture. A commitment to basic research, appropriately linked to Canada's industrial and commercial base, poses a challenge that is broader than structural reform at the NRC, necessary as that may be. As noted by the Conference Board, Canada ranks 15th out of 16 peer countries in business expenditures on R&D. The Jenkins Report crucially noted that

Effective collaboration between the business and higher education sectors de-pends on linking the "supply push" of research and discoveries with the "de-mand-pull" of firms seeking to exploit the commercial potential of new ideas. . . . [T]his involves not only firms, universities, colleges and polytechnics, but also a spectrum of intermediary players that belong to an innovation "ecosystem" char-acterized by effective synergies, connections, and flows of knowledge and ideas. This is a complex mix, not least because of diverging incentives and organizational cultures among different institutions. (Emphasis added.)[52]

In 1993, Professor Donald McFetridge of Carleton University surveyed Canada's innovation system con-cluded that "although they have been relatively effective in fulfilling their education and [basic] research functions . . . Canadian universities appear to have been less closely linked to the domestic industrial innovation system than are universities in other countries. . . . [the impression based on limited evidence is that] Canadian universities have not served the insulator/inclusional function that U.S. universities have and . . . technologies developed in Canadian universities are frequently exploited abroad rather than domestically." The Jenkins Report observed nearly two decades after McFetridge's observation that "Canada ranks near the bottom of OECD countries in terms of the proportion of businesses collabo-rating with universities for R&D."[54]

An extensive body of academic work and empirical research has arisen over the past generation con-cluding that national and regional cultures can play a decisive role in the relative success or failure of innovation in an economy.[55] Canada's mother countries, Britain and France, are each struggling with the damaging legacy of innovation cultures in which universities and other public research organizations, on the one hand, and industry, on the other hand, have traditionally operated in separate spheres, each regarding the other with suspicion or worse. In Britain a 2009 study by the University of Cambridge observed that "although British science is frequently lauded as being second only to the United States in capability, the gap between the research carried out in academia and its successful application commer-cially has vexed successive governments."[56] A 2006 study of innovation in France observed that "[T]he concern of public authorities about the lack of cooperation between national enterprises and publicly funded research institutes and their component institutes' laboratories is almost congenital to French national research policy."[57] Historically as in Canada, industry-funded R&D has been comparatively low.[58]

Both the UK and France are currently engaged in an effort to foster innovation, in part, through the difficult task of modifying an existing culture and embedded attitudes that act as a drag on innovation. Not surprisingly, they are focusing, in particular, on Germany, a prosperous, high-wage country which competes successfully at the global level and enjoys a manufacturing ratio as a share of GDP far higher than that of the United States. Various historical accounts of how Germany overtook Britain in industri-alization in the late Nineteenth and early Twentieth Centuries – many of them British – observe that "'the British did not innovate as rapidly or effectively," a phenomenon attributable to a tangle of deeply em-bedded attitudes and prejudices, in the case of Britain, and, on the other hand, the culture, history and innovation infrastructures of Germany.[59]

German universities emerged as centers for "serious research and scholarship in science and tech-nology long before their British and American counterparts."[60] The practical knowledge developed in an industrial context has been respected and incorporated into German university curricula for centuries, notwithstanding the lack of academic pedigree of some industry representatives.[61] German universities led the world in the Nineteenth Century in developing systematic methods for developing and transfer-ring scientific discoveries to industries like medicine, machinery and engineering. By 1900, German uni-versities were "providing the best technical and scientific training in the world."[62] In Germany, the tight

nexus established generations ago between universities and industry has been institutionally reinforced and strengthened down to the present day, with many professors actively engaged in manufacturing innovation. Emblematic of German innovation culture is the fact that "excellence on the shop floor is every bit as important as the Nobel Prize caliber laboratory," and that "managers trained in engineering or the sciences often feel they should be able to prove the mettle of their own skills in front of workers who have high standards against which to measure performance."[63]

The longstanding orientation of Germany's institutions of higher learning toward industry has been reciprocated by companies' awareness of and respect for the role that scientific knowledge can play in the success of their business. Germany's expert prowess is widely attributed to small and medium busi-nesses known as the Mittelstand, "one of the main factors that generated economic success and pros-perity in Germany after World War II.[64] The Mittelstand typically dominate the manufactured product sectors in which they operate – a 2007 study found that over 1,130 small and medium German compa-nies had the number one or number two position in the world market for their products or the number one position in the European market. [65]

The emergence of the Mittelstand in the Nineteenth Century is relevant in the present context. In the early 1800s, the industrial revolution was bringing about the demise of many handicraft industries across Europe. The challenge posed then is not entirely different from those faced by Canadian small business today in an era of rapid globalization. The states of southwest Germany, notably Baden and Württem-berg, responded by establishing decentralized networks of "formal, educationally-oriented, self-help institutions to disseminate information, technology and skill" and incorporate the automated production techniques of the industrial revolution. As a result, instead of disappearing, as elsewhere in Europe, local craft-oriented businesses began to thrive. The speed with which the new schools enhanced the quality and volume of local output "astounded" visiting German officials and led to "general acclaim" for Black Forest wood products at the Chicago World's Fair in 1893.[66] The German Empire eventu-

ally institutionalized the best practices of Baden and Württemberg throughout Germany. As artisanal businesses continued to mechanize and improve their technical proficiency, producing extremely high quality products, their social status rose, and they began referring to themselves as "Mittelstand" (middle class), carrying their innovation-based survival strategies down to the present day, where they face fierce competition from Asia.[67] The Mittelstand typically regard innovation as integral to their business model, and Germany's innova-tion infrastructure as key to their survival in a competitive global environment. Roth & Rau, for example, a 1,100-employee Mittelstand firm located near Dresden, specializes in niche products for the photo-voltaics industry, including machinery to make coatings for solar panels. A major market is China, and Roth & Rau understands that its machines will be copied there. "[The company] can't do anything about it. But they also know that duplicating the precision-coating process isn't easy, and this has given them a five-year jump on Chinese capability". The key to "keeping the gap," as a company executive puts it, is innovation and constant incremental improvements in the production process. For this, the company "is working closely with various Fraunhofer institutes." [68]
The German innovation culture, which has long been characterized by the systematic application of knowledge in an industrial and commercial context, may be admirable but, as has often been observed, difficult to emulate in fundamentally different cultures. But the evolution of German innovation policy has been heavily influenced by government policies and measures intended to break down barriers between the scientific community and industry. The German universities began incorporating prac-tical knowledge and teachers from industry into their curricula at the prodding of governments of the German states. The rise of the Mittelstand was enabled by the governments of Baden and Württemberg, and later, by other German states and the Kaiser,

in the form of new educational and technical institutes established to meet industry's needs.[69] The first Fraunhofer was established by the Bavarian government to boost the local mining industry, and the existence of the Fraunhofer network today still depends on state and federal "core" funding as well as contract research for government entities.

The British and French governments are seeking to address and change their respective innovation cultures in part through institutional mechanisms to bring the research and industry communities more closely together, as in Germany, occurs through organizations like the Fraunhofer as well as industry associations. Three examples from Britain:

- *Knowledge Transfer Partnerships (KTPs). KTPs, funded by grants, involve three actors: a UK-based company, a "knowledge-base partner" (usually a British university); and a university graduate ("KTP Associate") who is supervised by a mentor with the necessary technical skills ("Academic Supervisor"). The company designates a project, strategic in character, that it could not otherwise carry out without the knowledge-base partner, the KTP Associate works at the company to execute the project with the close supervision of the Academic Supervisor. About 1,000 KTPs are operating at a given time. Companies may or may not offer a job to the KTP Associates, but many do.*

- *Knowledge Transfer Networks (KTNs). KTNs are designed to raise national awareness of designated areas of technology and to connect companies in need of technology with elements in the knowledge base capable of delivering it. KTNs are funded by the government Technology Strategy Board.*

- *Knowledge Transfer Offices (KTOs). KTOs are established in British universities to disseminate relevant information about ongoing university research to compa-nies, nonprofits and government agencies. KTOs are supported by the govern-ment Higher Education Innovation Fund.*

(3) Innovation Intermediary Institutions.

Every advanced country that seeks to improve its innovation performance confronts a common chal-lenge – how to bridge the gap between basic research, which is typically conducted in universities and public and nonprofit research institutes, and the practical needs of industry. While culture, as noted, is a critically important factor, institutional mechanisms can play a vital role as well. A number of the most successful innovating countries, such as Germany and Taiwan, have created highly sophisticated insti-tutional intermediaries that systematically link their science base with industry, producing a constant flow of innovative products and industrial processes into the commercial realm. Reflecting their success in such "translational research," Germany's Fraunhofer Gesellschaft and Taiwan's Industrial Technology Research Institute (ITRI) are among the most studied research organizations in the world. Despite the common caveat that these organizations have flourished because they are embedded in economies and societies with unique characteristics that cannot easily be replicated elsewhere, efforts to emulate these intermediary models are under way in the United Kingdom ("Catapult"), France ("Carnot Institutes") and the United States ("National Network for Manufacturing Innovation" or NNMI).

Tom Brzustowski, a Canadian academic, engineer and civil servant who has written several books on innovation in Canada, has long observed that Canada is "largely missing two key structural components in its research network," which are corporate research laboratories (too few) and "not-for-profit orga-nizations that connect research with the market" such as Fraunhofer and ITRI (too few and too small).[70] Brzustowski's 2012 book, Why We Need More Innovation in Canada, highlighted some excellent existing Canadian nonprofit innovation intermediaries, but he concluded that:

> *We have lots of programs, active organizations, clusters, partnership and innovation intermediaries helping with the details of the innovation process. But there seems to be little capacity for helping innovators to achieve commercial success in world markets on a scale that will result in sustained new wealth creation in Canada.*[71]

According to the previous government's Minister of State for Science and Technology, the reorientation of the NRC toward applied research was based on the Fraunhofer model.[72] To the extent that the pro-gram recognized the need for publicly supported research support for industry it was consistent with that model. But if anything, the change arguably widened, rather than bridged, the gap between the basic research community and Canadian business, effectively relegating them institutionally to separate realms.[73] This is not the first time the Fraunhofer model has been misapplied.[74] Peter Howitt of the C.D. Howe consultancy, commented in 2013, that:

> *My recommendation endorses the government's recent reorientation of the NRC towards commercially relevant research but with the proviso that the NRC should actively engage university researchers in this process rather than expanding the independent research capability of the NRC.*[75]

The Fraunhofer and ITRI regard themselves a bridge from universities and other basic research institutes to industry – not as alternatives to them. ITRI is co-located with two of Taiwan's best basic scientific re-search universities, Tsing Hua and Chiao Tung. Faculty from these institutions sometimes take positions in ITRI's industrial development laboratories and many of ITRI's top managers serve as university faculty members. The two universities supply much of ITRI's engineering and scientific talent.[76] Researchers from the two universities are collaborating with ITRI industry on relevant projects in thematic areas such as biomedicine, system-on-a-chip, and wireless communications.[77]

Every one of Germany's Fraunhofer institutes is institutionally linked with one or more German research universities with research capabilities in the institute's area of focus, and the director of every Fraunhofer is a faculty member of the university partner. These director-professors typically identify the most prom-ising graduate students and postdocs in their university classes and steer them to part-time positions at the Fraunhofer. Challenges encountered in performing contract research for German companies be-come dissertation topics for such students, who identify basic scientific concepts the understanding of which may lead to progress in industry-related projects. The Fraunhofer institutes themselves are orga-nized to bridge the gap between the differing cultures of basic science and business, using multidisci-plinary teams with a mix of technical and business expertise as intermediaries.[78]

ITRI's and Fraunhofer's ties with industry are as close as those with universities. ITRI forms topical R&D alliances with Taiwanese companies to ensure that they monitor or participate in ITRI research projects and are ready to absorb and apply the research results. ITRI organizes small and medium companies to

orm supply chains for emerging new technologies in sectors like microelectronics, photovoltaics and flexible electronics. It offers prototyping and pilot manufacturing facilities to enable companies to pre-pare to commercialize newly-developed technologies.

The Fraunhofer performs contract research for industry on favorable terms, a particularly important function for small businesses with little or no internal research capability. Like ITRI, it offers prototyping, process simulation and pilot manufacturing services in thematic areas. Fraunhofer has also been in-volved with large German companies in multiple, inter-related projects over a time frame of many years. The Fraunhofer sponsors and supports offsite R&D centers located on company premises, forms joint ventures with companies, and in some cases accords companies "guest" status, enabling them to op-erate their own laboratories on the Fraunhofer's premises.[79] Both ITRI and Fraunhofer spin off pieces of themselves to create new companies, sometimes with spectacular success.[80]

The lasting achievements of the research intermediary organizations in Taiwan and Germany are worth noting. ITRI, "has played an integral role in transforming Taiwan's economy from a low-tech, labor inten-sive model to a high-tech, knowledge-based industrial core."[81] ITRI has virtually created entire industries and industry chains in semiconductors, photovoltaics, computers, lighting and displays.[82] Canada's Tom Brzustowski commented about ITRI in 2012 that:

> *Taiwan's population is two-thirds of Canada's and that means that if we don't mea-sure up to their performance we can't use the hackneyed excuse that 'We couldn't do the same thing because Canada is a small country. The National Research Council of Canada, which is our premier science and technology institution, has about 4,000 employees. ITRI is 50 percent larger.*[83]

The Fraunhofer is widely credited with Germany's success as an exporter of manufactured goods, its formidable reputation for quality engineering, and its ability to retain onshore manufacturing operations and jobs. In particular, it is seen as a key factor underlying the export strength of Germany's small and medium firms, including the so-called Mittelstand, "one of the main factors that generated economic success and prosperity in Germany after World War II."[85] "[T]he research facilities of the Fraunhofer serve as external, very well-equipped research departments of the Mittelstand companies."[86]

Support for innovation by small businesses. The Industrial Research Assistance Program (IRAP), admin-istered by the NRC, provides technical and business advisory services and distributes financial assis-tance to Canadian small businesses. IRAP's operations were studied and praised as "best practices" in a 2013 study of innovation in manufacturing by the U.S. National Academy of Sciences.[87] The key to its success in effectively bridging the gap between Canada's research base and small companies is "a small, elite cadre of about 230 Industrial Technology Advisors," with industrial R&D experience, and strong relevant educational backgrounds. The Advisors select companies to receive funding and provide net-working, technological and business advice as well as competitive intelligence.[88]

David Watters, who worked for over 30 years in Canadian federal public service and now heads the Ottawa Consultancy Global Advantage Consulting Group, participated in the 2013 U.S. National Acade-mies study that examined IRAP. He noted IRAP's growing international reputation and its recognition as a "best practice" by the Council of Canadian Academies. But he also noted areas for improvement:

- *IRAP is providing support for 89,000 Canadian SMEs but the country has 75,000 technology-oriented SMEs, and IRAP may only be reaching a small fraction of its potential market.*

- *The Jenkins Report, while lauding IRAP in general, criticized its tendency to exhaust its funds early in each fiscal year, the complexity of its application process, and the fact that its awards are often too small to be effective.*

- *IRAP has not articulated a strategy for balancing between assistance to startups and small SMEs versus multiple rounds of funding for mature SMEs who have already demonstrated capacity to perform.*[89]

IRAP is a success story in an area in which Canada needs success, knowledge-based innovation by in-dustry. Its budgets should increase and internal reforms should be implemented (such as simplification of the application process for SMEs).

(4) Improving the protection of intellectual property.

> A robust climate for innovation is only possible if Canada's regulatory processes en-courage the development and launch of innovative products and if our laws ensure that inventors and those who invest in their ideas can fairly reap the rewards of their work. Canada should aim for a reputation as the best place in the world in which to research, develop and bring to market new products and processes. To achieve that goal, it is imperative that Canada seize current opportunities to improve its protection of intellectual property and thereby create a more attractive environment for investment in innovation.[90]

Patent law and policy provide the basic framework with which innovation does or does not take place. If the legal framework offers the innovator a reasonable certainty that he or she can reap the benefits of a commercially successful invention, innovation is likely to occur. To the extent that the law offers only un-certainty, innovations and the investments necessary for commercialization are less likely to occur. This is particularly true with respect to innovations involving high levels of risk and large initial investments.

Over the last four years, the Government of Canada has prioritized the modernization of Canada's IP regime. On copyright, in 2012, Canada completed one of its most significant policy reforms with the Copyright Modernization Act. With the implementation of the Trans Pacific Partnership (TPP) agreement, Canada will extend the term of copyright protection to Life of the Author plus 70 years. In 2014, Can-ada's IP laws were amended to align with five international IP treaties to harmonize and streamline IP administration procedures. As part of the Comprehensive Economic and Trade Agreement with the Eu-ropean Union, Canada has committed to three key obligations related to pharmaceuticals: an additional period of protection for eligible pharmaceutical patents, measures to ensure litigants have equivalent and effective appeal rights under the patent linkage regulations, and an eight-year data protection term for biologics and chemical drugs. In addition, regulatory changes were enacted following a Court ruling to clarify protection for innovative combination drugs.[91]

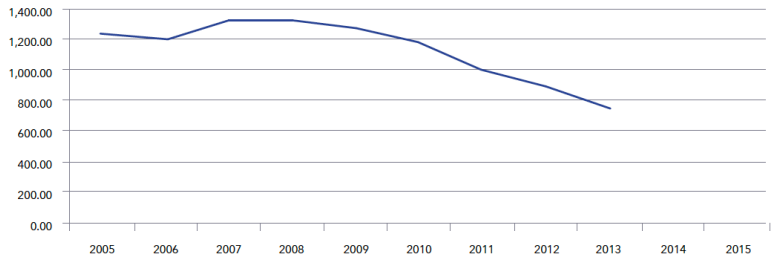
Nevertheless, several aspects of Canadian patent law and policy magnify the uncertainty confronting innovators and arguably act as a drag on commercially-relevant innovation and venture investments.

Through a series of decisions over the past decade, Canada's federal courts have developed the so-called "promise" interpretation of patent utility (the notion that a product must be useful to warrant issuance of a patent), in which the court finds an implied promise by the patentee that a patented tech-nology will perform in a certain way in the future, or the patent may be invalidated. Because the po-tential applications of new technologies cannot necessarily be foreseen at the time of patent issuance, the patentee faces the prospect of losing patent protection in the future due to the vagaries of evolving technologies and the rulings of whatever court or courts hears challenges to the patent. A court coming in years after a patented drug has been in use, successfully in thousands if not hundreds of thousands of cases and invalidating the patent on the basis of the insufficiency of the claims made at the time of patenting is worse than highly disruptive, it must be judged to impair the willingness of companies to invest in R&D in Canada. By its very nature, this doctrine increases the risk of innovation and therefore may deter it altogether.[92]

In pharmaceuticals, the most research-intensive of all industries, those who discover new and promising drugs must patent them quickly or the discovery will be appropriated by others. However, in the early stages of development, the potential uses and side effects of a drug are often unknown and unknow-able. The innovator faces the prospect that years after a drug has come into use, and massive invest-ments committed to research and trials, the patent can be invalidated by a court passing judgment on the sufficiency of claims made at the time a drug was patented. This doctrine is disruptive in individual cases and overall constitutes a deterrent to R&D investments in Canada. It is not too much to conclude that Canada's pharmaceutical sector is underper-forming by most measures. It is vital to the future of Canada's future in biotechnology and pharmaceuticals to look for the causes, which must necessarily include the application of the promise doctrine.[93]

The patent promise/utility doctrine has implications for industries outside the pharmaceuticals sector, but it is the pharmaceutical industry that has borne the brunt of invalidations under the promise doctrine.[94]

R&D expenditures in Canada by holders of Canadian pharmaceutical patents ($ million)



The example of biologics. One of the most promising areas of innovations in medicine is the develop-ment of biologics, medicines that use live natural microorganisms to produce a pharmaceutical product. The following are a few of the benefits of the research in this area:

- deciphering pathways of disease,
- finding patterns in how genes respond to drugs,
- determining the state of individual's health and likely responses to drugs to personalize medicine,
- genetically creating antibodies to cut off oxygen to cancer cells,
- creating a vaccine to present cervical and other cancers,
- inducing an enhanced immune response against prostate cancer,
- creating antibodies to treat specific diseases, such as lupus, and
- targeting Hodgkins lymphoma with an antibody.

In addition to these known benefits, biologics hold out promise of future treatments for many of the most serious human diseases and conditions. Reflecting in substantial part Canada's superb medical research capabilities, biologic drugs are one of Canada's fastest-growing market sectors, with a 12.2 per-cent growth rate for the 12 months ended August 2014 compared with a 3 percent growth for all drugs during the same period.[96]

Between 2000 and 2007, the Canadian government made major investments in genomic research which served as a catalyst for the emergence of a domestic biopharmaceutical industry.[97] This field, in which scale matters less than ingenuity, saw the emergence of many small entrepreneurial firms commer-cializing discoveries made in Canada's research base. Canadian biopharma small and medium enter-prises (SMEs) developed one of the world's strongest R&D pipelines, with over 800 products in various stages of research and development. Many of these companies are reportedly struggling, however, to make the transition from "early stage research into viable commercial positions."[98] The Canadian gov-ernment observes that

> *Historically Canada has produced proportionately many more early-phase bio-pharmaceutical companies than the United States, and other countries with vibrant biotech industries. However the lengthy and risky path to product de-velopment and commercialization, the large amounts of capital required, and the difficulty in obtaining such capital have led to a contraction in the number of such firms in Canada.*[99]

One of the risk factors for such companies cited by the government is the "lack of certainty" with respect to the soundness of patents, citing specifically the "utility requirement."[100]

It is not lost on foreign governments that biotech is a vitally important not only from a perspective of health, but for the sector's contribution to economic growth. To cite a few examples:

> *Due for completion in 2015, the National Biologics Manufacturing Centre (NBMC) is part of the government's Strategy for UK Life Sciences, which was launched by prime minister David Cameron in 2011 and updated last year.*[101]

And in China:

> *The bio-industry has been designated as one of China's seven strategic emerging industries (SEI) by the government. Within the bio-industry, therapeutic biologics hold significant promise for China*

to achieve breakthrough innovation and to address largely unmet medical needs in many disease areas, including diabetes, cancer, hemophilia, and immunological impairment.

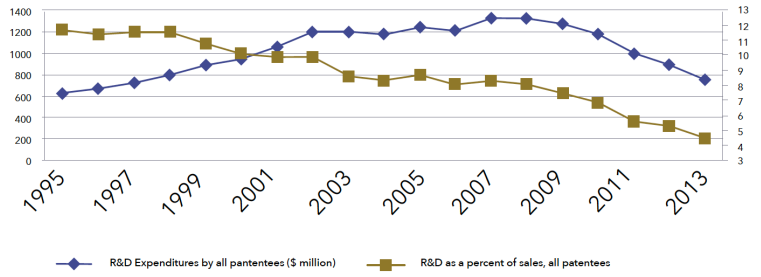
More is required than government funding and support for R&D, also essential is a necessarily high level of protection of intellectual property.

Implications for Canada. Investments in pharmaceutical R&D in Canada are declining in absolute amounts and as a percent of company revenues. Canada's Patented Medicine Prices Review Board (PMPRB) surveys R&D expenditures in Canada by companies holding patents on medicines. Its sur-veys depict a pattern of generally increasing expenditures from 1995 through 2007, with a leveling off in 2008 and an accelerating decline thereafter. Canadian pharmaceutical R&D outlays in 2013 were at their lowest level since 1997. R&D outlays as a percent of sales have also declined dramatically, from annual levels of 10-11 per-cent in the 1990s to 4.5 percent in 2013.

Year	R&D Expenditures by All Patentees ($ million)	R&D as a Percent of Sales, All Patentees
1995	625.5	11.7
1996	665.3	11.4
1997	725.1	11.5
1998	798.9	11.5
1999	894.6	10.8
2000	941.8	10.1
2001	1,060.1	9.9
2002	1,198.7	9.9
2003	1,194.3	8.6
2004	1,170.0	8.3
2005	1,234.3	8.7
2006	1,210.0	8.1
2007	1,325.0	8.3
2008	1,319.7	8.1
2009	1,272.0	7.5
2010	1,178.2	6.9
2011	997.7	5.6
2012	894.8	5.3
2013	752.8	4.5

Shown graphically, it can be seen that R&D expenditures by all patent-holders as a percent of GDP has declined markedly since 2007, and as percent of sales has been declining since 1998.

R&D expenditures by all patentees



R&D spending by Canadian pharmaceutical patentees contrasts sharply with domestic R&D spending by innovative U.S. biopharmaceutical manufacturers. Members of PhRMA, which is comprised of inno-vating firms committed to strong IP protection nearly quadrupled their total domestic R&D spending during the same time frame, and also increased their R&D as a percent of domestic sales.

The purpose of the WTO Trade-Related Intellectual Property(TRIPS) agreement and the Trans Pacific Partnership IP provisions is to help create a strong proinnovation environment through in large part the protection of intellectual property. The entire economy benefits from innovation, and innovation rests on intellectual property. Every country is looking for ways to improve its economic growth through inno-vation. Canada now has a fresh opportunity continue to do so.[103]

Generics. Canada has a vibrant and competitive generic drug industry which accounts for 66 percent of Canadian prescriptions but only 23.5% of Canadian spending on prescription drugs, reflecting the lower prices of generics. The patented and generic drug industries are not alternatives to each other, but complementary elements of the healthcare system; generic drugs play a key role in reducing the cost of healthcare, while patented drugs lead the way in expanding the scope of treatments as well as reducing the need for hospitalizations and surgery. In the United States, which has the world's leading patenting biopharmaceutical industry, many patented drug producers operate their own generic drug affiliates, and generic drugs account for 88 percent of all prescription drugs dispensed – a higher pro-portion than Canada. A 2009 study of innovation in Canada by the Council of Canadian Academies stated that Canada's

> *Generic pharmaceutical manufacturers represent more than 15% of industry sales and 40% of volume, but do relatively little R&D (This R&D is aimed primarily at copying established medicines whose patents are about to expire.). Canadian generic firms are nevertheless quite competitive and export a significant propor-tion of their drugs.*[105]

Canadian generic drug makers are under cost pressure from governments and insurers.[106] Generic drug makers have responded by outsourcing some of their drug manufacturing operations and sourcing of drug ingredients to lower-cost countries. India, which now supplies 5 percent of Canada's finished drugs (about 20 million annual prescriptions) has labor costs about one-tenth those of Canada.[107] Alan Cassels, a drug policy researcher at the University of Victoria, commented in 2012 that "most prescrip-tion drugs" consumed in Canada are "manufactured overseas."[108] The extent to which Canadian ge-neric drug production and sourcing of ingredients has moved and continues to move offshore is most frequently highlighted on the rare occasions when tainted drugs are discovered.[109] Such incidents also underscore the fact that their formulas for generic drugs, which are derived from research performed by branded pharmaceutical firms, increasingly support manufacturing operations and employment which takes place in Asia rather than in Canada.

Patent policy reform in the U.S. U.S. policies do not necessarily offer good models for Canada, but the occasional policy pitfalls encountered in the U.S., and the nature and effects of the corrective actions eventually taken, deserve consideration. In the Twentieth Century, U.S. courts systematically weakened patent protections for innovations, as is now occurring in Canada, although the U.S. judiciary was pri-marily motivated by antimonopoly concerns rather than interpretations of patent utility. The net result was similar, however – the creation of progressively greater uncertainty and risk for innovators with re-spect to the availability of patent protection. As patent protections eroded, the U.S. economy staggered, reaching a nadir in the 1970s which a number of leading U.S. academics attributed to a decline in innovation. Significantly, legislative policy measures introduced in a relatively short period (198082), paral-leled by two key Supreme Court decisions, heralded a dramatic surge in innovation and the creation of entire new high-tech industries, most notably biotechnology.

The founders of the United States regarded innovation as so vital to the future of the new republic that they provided for protection of intellectual property rights in the Constitution, giving Congress the au-thority to "promote the Progress of Science and the useful Arts by securing for limited times to Authors and Inventors the exclusive Rights to their respective writings and discoveries."[110] Throughout the Nine-teenth and early Twentieth centuries, American inventors, aware that the patent system would reward their creativity, produced a succession of breakthrough technologies, including the steamboat, the tele-graph, the electric light, the telephone and the airplane.[111]

In the early Twentieth Century, however, U.S. courts, increasingly suspicious of big business, began to override patent rights in judicial decisions. The courts came to view patents as sources of monopoly power and "measures were taken to weaken patent rights."[112] Most U.S. patents that were subjected to challenge in the courts during the anti-patent era were declared invalid. A Supreme Court justice com-mented in 1949 that "the only patent that is valid is one this Court has not been able to get its hands on."[113] Judicial hostility to patent rights was reinforced by the U.S. competition agencies, and in 1970 the Department of Justice issued the so-called "Nine No-Nos," declaring nine practices associated with the exercise of intellectual property rights and licensing of IPR as per se illegal.[114] The erosion of patent rights at the hands of the judiciary and government antitrust enforcers was decried by Cana-dian (and later American) John Kenneth Galbraith and other prominent Americans, but without con-temporaneous effect.[115]

In the 1970s, with the U.S. economy mired in seemingly intractable "stagflation," a fundamental reas-sessment of existing U.S. policies toward intellectual property rights occurred.

The Chicago School of economists criticized judicial application of antitrust rules in a manner which was hostile to intellectual property rights and called for a reappraisal of U.S. patent rules in light of "general concern about indus-trial stagnation and lack of significant technological innovations."[116] An advisory committee established by President Carter to examine U.S. innovation policy concluded that "diminished patent incentive was a factor underlying national economic stagnation."[117]

Reflecting changing public views toward patent rights and innovation, in the early and mid1980s Con-gress and the Executive took actions which broadened the exclusive rights of inventors to exploit their inventions in the United States. These measures included the creation of the Court of Appeals for the Federal Circuit (1982), with exclusive jurisdiction over all appeals of federal district court decisions involving patents, with the result that pat-ents were upheld more frequently; the enactment of the Bayh-Dole Act in 1980, enabling researchers receiving government grants or contracts to more readily secure patent rights on their creations; and overhaul of the U.S. competition agencies' patent policies with acknowledgement that protection of patent rights could have major pro-competitive effects.[118] Looking back on the U.S. experience from the perspective of 2002, The Economist commented that:

> *[P]ossibly the most inspired piece of legislation to be enacted in America over the past half century was the Bayh-Dole Act of 1980 . . . more than anything, this single policy measure helped to reverse America's slide into industrial irrelevance.*[119]

Bayh-Dole, in particular, had a positive impact on local economies in areas where federally-funded R&D was under way in universities, and research organizations and small businesses.[120] Enactment of Bayh-Dole encour-aged many U.S. universities to establish or expand their technology transfer offices in order to commercialize their research. The number of patents issued to U.S. universities skyrocketed from about 250 per year prior to Bayh-Dole to 1,600 in 1993 and over 3,000 in 2000, trends which were mirrored in licensing agreements with companies.[121] The net effect was to stimulate local economies as the universities spun off an increasing number of new companies and licensed technologies to existing local firms. A 2012 study by the Center for Economic Studies at Harvard examined U.S. census data to assess the impact of Bayh-Dole on counties surrounding uni-versities which conducted federally-funded research. The study found that:

> *[E]mployment, payroll and average wages grow differentially faster after the Bayh-Dole Act in industries more closely related to the technological strengths of nearby universities. The magnitudes . . . are consid-erable and grow with proximity to the university supporting the importance of spatial relationships in the spread of knowl-edge. Areas surrounding universities that received more federal research funding before the law was passed grow faster after the law than do others. The effect is particularly large for DOD and NIH funding.*[122]

Bayh-Dole also stimulated innovation by startups and small businesses receiving federal research funding. Pri-or to Bayh-Dole, the federal government retained patent rights for technologies developed by small businesses, whereas after enactment of legislation, startups and established small firms could patent and exploit the fruits of their federally-funded research without the need to negotiate a license with the federal government. Most federal funding of small business innovation takes place under the auspices of the Small Business Innovation Research Program (SBIR). According to the U.S. Defense Tech-nical Information Center, between the effective date of Bayh-Dole in 1981 and 2012, over 67,000 pat-ents have been issued to small U.S. businesses performing research pursuant to federal SBIR grants.[123]

The 1980s changes in the U.S. judicial stance towards patents were a key factor in the dramatic emer-gence and growth of high-technology industries which occurred in the U.S. during and after the 1980s. Two Supreme Court decisions in 1980-81 significantly extended the scope of patentable subject matter. For what were in 1980 nascent industries such as semiconductors, software and biotech, the Supreme Court decisions were "a driving force behind a series of legal precedents and legal reforms which re-sulted in broader and stronger patent and copyright coverage of new life forms, semiconductor de-signs, software programs and nanotechnologies." Strengthened patent protection played a particularly powerful role in helping create an entirely new U.S. industry, biotechnology. The 1980 Supreme Court decision in Diamond v. Chakrabarty to the effect that biological inventions could be protected by patents had major consequences.

Biotech industry leaders "generally credit the Court's decision in Chakrabarty as the beginning of their industry without which genetic engineering would not have made nearly as much progress."[126]

> *"Without patent protection, the venture capital which has been critical in fostering the [biotechnology] industry would not have been available. This entire industry, in which the United States is the clear leader, would have languished."*

In 1980, the year U.S. patent policy began to change in the direction of strengthened protection for new discoveries, eight out of ten of the world's then-top ten drugs had been discovered in Europe.[128] How-ever, the changes in U.S. legal and regulatory structures during the 1980s "gave rise to an environment that was more conducive to innovation than was the case in Europe." While small firms and universi-ties in Europe were encountering difficulty in commercializing new drugs, patent policy reforms were opening up opportunities in the United States. The U.S. came to dominate the emerging biopharmaceu-tical industry, which in 2011 accounted for 650,000 U.S. jobs and $900 billion in economic output.[129] By the decade of 2001 to 2010 the United States had reversed the prior European lead in the production of wholly-innovative "new chemical entities."[130]

Over time, U.S. policymakers have come to recognize that inadequate patent protection and judicial-ly-imposed limits on the exclusive rights of patent-holders were powerful disincentives to innovation. A U.S. antitrust enforcer observed in 2007 that:

> *If the inventor [in a discovery] commits funds and the investment fails, it absorbs the entire loss; it does not receive any subsidy from its competitors. But if the investor commits funds and the investment succeeds, it must now share the benefits with its competitors. An asymmetrical system of this type discourages entrepreneurial risktaking, encourages free-riding, and becomes what one of your commentators has called "an insurance policy for laggards". To assure that investments and inno-vations are not discouraged, competitors must be confident in advance that they will not be required to share their successful assets with competitors.*[131]

Rationalizing Canadian IPR policy. To the extent that parallels exist between Canada's situation today and that of the United States in the mid-Twentieth Century, they are most evident with respect to the uncertainties and risks for innovation created by evolving judicial decisions, which relegated patent protections for innovators to a distinctly secondary position.

In the United States, corrective action was eventually taken by legislation and policy reinterpretations implemented by the executive branch, and Canada may wish to consider a similar approach.

With respect to federally-funded research, Canada does not have the equivalent of the U.S. Bayh-Dole legislation, which established a uniform and clear set of rules applicable to all federal agencies with respect to the patent ownership of the results of federally-funded research. Each Canadian public re-search funding entity has its own rules, with some retaining ownership and granting licenses and others allowing ownership transfer to a university or research center.[132]

Bayh-Dole type legislation is not a panacea for low national levels of innovation, and nations which have enacted similar legislation have experienced mixed results. Institutional, historical and cultural factors may limit the extent to which the U.S. experience can be replicated elsewhere. However in a Cana-dian context the potential effects of legislation to use intellectual property rights to increase innovation incentives for researchers should be studied by the Canadian government, recognizing that a number of factors that appear to underlie U.S. success are also found in Canada (excellent research universities, dynamic small businesses, the ability to attract talented immigrants, solid institutions and infrastructure). An executive at Calgary-based software firm Solium Capital observed in 2011 that Canada's lack of legislation establishing clear IPR rules for federally-funded research was a "key barrier to greater univer-sity commercialization":

> *"There's no national strategy, no will at the federal level". Since researchers often struggle to understand what rights they have and must negotiate the terms and conditions for licensing their inventions, "what happens 80 percent of the time is nothing happens.". . . More often than not, their IP ends up gathering dust.*[133]

While changes in the law are probably needed, they are not enough. As the Action Plan for Prosperity concluded:

> *Beyond legal and regulatory changes, businesses need consistent, timely and rele-vant treatment of intellectual property developed at post-secondary institutions. IP policies at institutions and granting agencies, including those dealing with disclo-sure and licensing, must facilitate collaborative research and encourage innovation. The business and academic sectors should launch a national dialogue aimed at creating a clear and consistent framework for IP agreements between individual companies and institutions.*

(5) Access to risk capital

The Jenkins Report identified a "risk capital gap" for Canada, a shortage of "funding of innovation-fo-cused businesses from start-up through maturity." Canadian venture capital funds were of "subscale size," angel networks were underdeveloped, and in general Canadian innovating firms were not as well financed as their U.S. counterparts. These findings paralleled those of the 2009 innovation study by the Council of Canadian Academies which noted with concern that

> *The relatively weak state of the Canadian VC industry mirrors a large U.S.-Canada performance gap. Canadian funds have significantly lagged their U.S. counterparts across virtually every time period for as long as data have been tracked.*[136]

In 2015, the Business Development Bank of Canada observed that many "high impact" Canadian firms "have difficulty obtaining higher risk financing, such as obtaining capital as flexible terms for new projects or markets."[137]

The Jenkins Report correctly observed that the issues affecting Canada's weak performance in risk capital are complex and that government intervention, if any, should be undertaken cautiously and in a "carefully structured manner" to avoid unintended harm.[138] Since the Jenkins Report, the Government has undertaken a number of programs to provide financial support for Canadian businesses, including the Canadian Accelerator and Incubator Program (CAIP), BDC Strategic Investments Partnerships, and the Venture Capital Action Plan (VCAP). Some significant Canadian pension funds are now important investors in VCAP. The current Government has committed to expanding support for the Industrial Re-search Assistance Program (IRAP), which could include the implementation of a Small Business Innova-tion and Research Program modeled after similar programs in the US, Australia and Japan.

However, more can be done. The new government should consider additional measures to close the risk capital gap recognizing that many possibilities exist. For example the Toronto Star observed in Oc-tober 2015 that "Canada's huge public pension funds have been largely absent on the nation-building front. Together they hold about $700 billion in assets that could play the role that lifted Google and Facebook from obscurity to ubiquity. Instead, they dote overly on low-risk real estate and infrastructure, much of it abroad."[139] The Canadian Chambers of Commerce is calling for a tax exemption for capital gains from venture capital investments.[140]

SBIR/STTR. A 2009 paper by Jorge Niori at the Université du Québec à Montréal, urges Canadian pol-icymakers to study the U.S. Small Business Innovation Research (SBIR) program, which provides early stage funding for startups and small businesses with innovative research proposals.[141] While some beginnings have been made as noted above Canadian investments of this kind are small in comparison with U.S. SBIR programs. In the United States the program became nationwide in 1982. Currently 11 Federal agencies participate. Between the Small Business Innovation Research (SBIR) and Small Tech-nology Transfer Research (STTR) programs that support the R&D financing of cutting-edge technologies, approximately US$ 2.2 billion is annually set aside. 145,000 awards have been granted amounting to some US$ 40 billion since the program started, with results shown in part by the approximately 10 patents per day that emerge from these programs The amount of SBIR funding is currently set at 2.9% of Federal agencies extramural R&D budgets greater than US$100M per year (FY 2015 growing to 3.2% by 2017. The STTR program is a sister set-aside program to facilitate cooperative R&D between small busi-ness concerns and U.S. research institutions – with potential for commercialization. Under this program 0.35% of the extramural research budget (>US$250 million) for all agencies with a budget greater than US$1B per year growing to 0.4% by 2017.

One of the most remarkable success stories is the SBIR grant to Qualcomm, a company with annual revenues in excess of $24 billion that specializes in the development and commercialization of a dig-ital communication technology called CDMA (Code Division Multiple Access).Based on wireless con-nections, CDMA and TDMA (Time Division Multiple Access), of which GSM (Global System for Mobile Communications) is the primary commercial form, are the primary digital technologies currently used to transmit a wireless device user's voice or data over radio waves using a public cellular wireless network. One of the most remarkable success stories is the SBIR grant to Qualcomm, a company with annual revenues in excess of $24 billion that specializes in the development and commercialization of a digital communication technology called

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The way in which SBIR operates is to provide Milestone-Driven Awards:

Phase I | Feasibility Study or Prototype
~$150 thousand and 6 months

Phase II | Full Research and Development Effort
~$1 million and 24 months

Phase III | Commercialization Effort
Private and Non-SBIR Allocated Financing

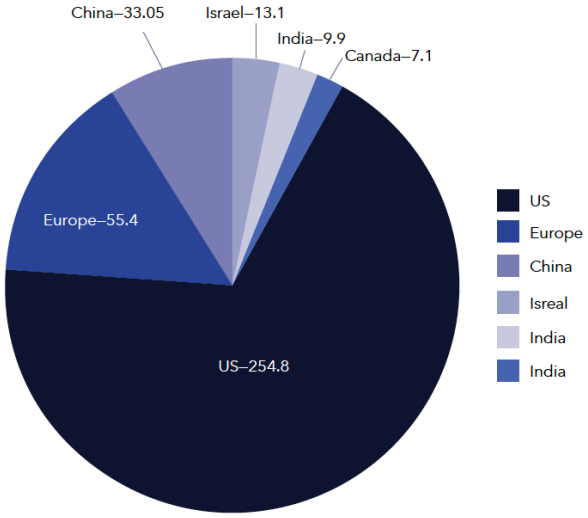
Under SBIR, the recipient must be primarily an R&D organization. Average firm size consists of nine employees. As they get larger (over 30 employees) there is an emphasis on product development and sales in addition to R&D. The grants focus on performing R&D, not for purchasing equipment, commercializing a technology that has already been developed, or one that has very low risk and only needs capital.[143]

Venture Capital. The launch of the venture capital fund of funds named the Northleaf Venture Cata-lyst Fund under Canada's Venture Capital Action Plan (VCAP), with Canada Pension Plan Investment Board and provincial government participation, is a significant step forward in filling an important gap in the funding of Canadian start-ups. The target funding and cap is C$300 million,[144] which has been reached.[145] This was followed by three other VCAP-supported fund of funds, the last of which is Har-bourVest Canada Growth Fund with a mix of investments from institutional and corporate investors, as well as Federal government and pension fund participation. This Fund is aimed at companies engaged in fostering information and communications technologies.[146] Almost a year ago Canada Pension Plan Investment Board signs acquired Antares Capital from GE Capital Corporation for US$12 billion.[147] This appears to be a global rather than a Canada-focused investment.

Recognizing that Canada has made efforts in recent years to improve its venture capital investments, there is a significant lag to overcome. During the period 2006-2013 the World Economic Forum pro-vided comparative data on six countries.[148]

Top countries for total venture capital invested

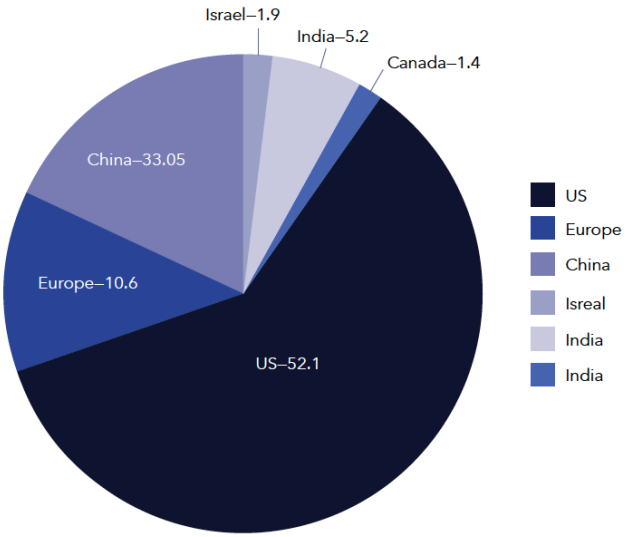
Share of total venture capital invested 2006-2013, $ billions



And in 2014:

Top countries for total venture capital invested

Share of total venture capital invested 2014, $ billions



Looking at eight years of data, the Canada-U.S ratio for venture capital is 2.8%. For 2014, the Cana-da-U.S. ratio is only 1.45% of U.S. While 2014 may be anomalous as a slow growth year for Canada actually it was the same growth rate as that experienced by the United States. More troubling is the fact that on these charts Canada had venture capital investments equal to 72% of India's VC investments during the period 2006-2013, but in 2014 Canada slipped to only 27% of India's VC investments. It is not that India was spurting ahead (India as compared with China was at 30% for the eight year period and 33.5% for 2014). Venture capital in Canada was simply investing less than was the case for other countries in this comparison.

The question remains: can the pension funds do more?

Crowdfunding. One additional avenue may be crowdfunding where ideas are put to the public, and a large number of investors contribute small sums. The numbers for Canada for crowdfunding look more promising than they are with respect to share of global venture capital. In 2012 Canada raised about 9% of the amount raised in the United States by this means, but exceeded India by 3X, China by 4X, and Japan by 6X. Crowdfunding is still in its infancy, but it is not insignificant, reaching US$2.8 billion worldwide in 2012.[150]

Scaling up. This is a challenge not in any way unique to Canada. In the UK, a Scale-Up Report[151] pre-pared for the British government in 2014 made the following observation:

> *Getting our ecosystem to produce a greater number of scale-ups is more ambitious and challenging than producing a greater number of start-ups or celebrating entre-preneurs. Abundant evidence from countries around the world shows that collabo-rative initiatives can 'super-charge' an economy to increase the ability of companies to scale-up and to make superior contributions to the economy.*

This report defines a 'scale-up' as "an enterprise with average annualised growth in employees or turn-over greater than 20 percent per annum over a three year period. and with more than 10 employees at the beginning of the observation period." The Report has wide-ranging recommendations including the provision of data of target companies so that government and private sector know of opportunities for these investments, report on successes, dedicate more of government funding of entrepreneurship to this phase, emphasize education in ba-sic skills, and make visas more readily available for these com-panies for recruiting abroad; private enterprise should work with universities on leadership develop-ment; use should be made government procurement, trade missions, and regulatory reform to focus on scaling up start-ups. The above listing of recommendations is not put forward with endorsement, but to indicate that other countries are concerned with the scaling-up hurdle and are thinking about possible solutions. Efforts should be made focused on the innovation gap in Canada, seek-ing public input, con-tracting to have studies done and reporting to agencies such as the National Research Council that can implement recommendations.

(6) Clean tech innovation

Although Canada is among the world's leading producers of fossil fuels, it is also a leader in the use of renew-able energy, which currently comprises about 18.9 percent of its total primary energy supply.[152] In 2014 Canada ranked sixth globally in investment in new domestic clean energy generation projects.[153] These investments are substantially attributable to supportive policies by provincial governments, such as mandates for specific target percentages of renewable power generation and feed-in tariffs. Clean Tech Canada, a think tank based at Simon Fraser University, stated in a report released in 2016 that

> *[W]hen it comes to policy, the provinces are doing all the heavy lifting. With the exception of Sustainable Development Technology Canada [SDTC], a fed-erally funded agency that provides critical early-stage financing to clean energy innovators, Ottawa remains largely indifferent to the opportunities of the clean energy revolution.*[154]

Clean Energy Canada observes that the country is "punching above its weight" in fostering a climate of clean-tech innovation – ranked 7th out of 40 countries, and ahead of Germany and Japan – despite "a lack of strong supportive federal policies. With respect to commercialization "we're not keeping pace on cleantech-specific drivers," resulting in a lower ranking.[155] Some government programs exist to support commercialization. In addition to the federally funded SDTC – which resembles the US ARPAE – sev-eral provinces fund early-stage innovation, primarily pilot and demonstration projects.[156] Budget 2016 proposes to provide over $1 billion over four years, starting in 2017–18, to support clean technology, including in the forestry, fisheries, mining, energy and agriculture sectors. But given the rapid adop-tion of clean technologies worldwide, Canada's natural re-newable energy resource advantages, and its favorable investment climate for clean technology innovation, the question remains how best to deploy this new funding, whether it is adequate, and what additional or modified federal policies might enable Canada to emerge as a world leader in renewable energy technologies. Research intermediary organi-zations in two countries which are world leaders in specific areas of renewable technology, Germany and Britain, may offer insight into what Canadian federal initiatives might achieve.

Germany – photovoltaics. "German companies lead the world in solar research and technology."[157] The fact that "Germany already boasts some leading research institutions with research interests in [photo-voltaics]." Signifi-cantly, foreign photovoltaic firms such as Arise Technologies (Canada) and Evergreen Solar (U.S.) chose to build their first manufacturing plants in Germany rather than their own countries.[158]

Germany offers unparalleled research and technological support infrastructure for solar energy com-panies, large and small. Germany's Fraunhofer Institut für Solare Energiesysteme ISE is Europe's largest solar energy research institute, with 1,100 employees, and offices, laboratories and test fields covering 27,000 square meters. Its research projects focus on energy efficiency, conversion, distribu-tion and storage on an environmentally sound basis. It operates five accredited testing units for solar thermal, photovoltaic and power electronics technologies. Funded by government and industry, its projects are all intended to result in commercial or other practical applications in a relatively short time frame, e.g., two years. It has spun off a number of new com-panies and its alumni commonly migrate to jobs in the solar energy field.[159] In 2015 Fraunhofer ISE set a new world record for solar energy con-version efficiency.[160] The previous year Fraunhofer ISE had set a world record for photovoltaic solar module efficiency.[161]

New Fraunhofers are created at initially-modest scale and grow as the demand for their research ser-vices by industry and government increases. In some cases, existing research organizations have been incorporat-ed into the Fraunhofer network, rebranded, and given a mission of supporting industry inno-vation in a given technology area.[162] Canada need not replicate the Fraunhofer ISE's sheer scale in order to capture many of the benefits that institution provides for the renewables industry – the key factor is the existence of sufficient readily-accessible technical support to enable Canadian renewables firms to compete at the global level. As in Germany, this may be achievable through redirection and reinforce-ment of an existing research organization.

United Kingdom – energy from the ocean. Canada is bounded on three sides by oceans which rep-resents a vast potential source of energy from ocean waves, tidal movement, and offshore wind.[163] The United Kingdom is similarly surrounded by ocean and seas, and has capitalized on this advantage, cre-ating world-leading government programs to foster innovation in offshore wind, tidal and wave energy technologies. The U.K. has an intrinsic potential competitive advantage in offshore renewable energy because its offshore fossil fuels companies already possess a wealth of practical expertise in operating in extreme ocean environments (e.g., the North Sea), and this experience is applicable to new forms of offshore energy development. At present, the UK is the world leader in offshore wind energy gen-eration, with as much installed capacity as the rest of the world combined.[164] It is also the "undisputed global leader" in marine energy, R&D with roughly 10 MW of wave and tidal devices being tested in UK waters, more than the rest of the world combined.[165] The government is backing the renewables sector with innovation infrastructure.

In 2010, the UK government announced the launch of a network of "Catapult Centres". Their mission is to translate learning from the country's knowledge base into practical applications in designated tech-nology areas. Initially government funded, the Catapults are eventually expected to be self-sustaining on the basis of research, development, demonstration and testing services provided to the private sector, academia and gov-ernment entities. The Catapults are autonomous, well-equipped organizations based at physical sites which provide clients with "the best technical expertise, infrastructure, skills and equipment that would otherwise be outside the reach of individual companies."[166]

The idea behind the Catapult concept was to pick a handful of sectors where Britain could aspire to global leadership, based on its existing capabilities of industry and natural endowments. Sectors were picked based on criteria which included world-leading research capabilities in the field, large global markets for the technol-ogy, existence of an industry base in the country capable of capturing a "sig-nificant share of the value chain," and alignment with national priorities.[167] The Catapult initiative did not aspire to create entirely new research organizations, but to identify a half-dozen or so existing insti-tutions good enough to "operate on a world stage," and provide them with additional resources and a clear mandate to make available to British industry in the selected sector access to "the best tech-nical expertise, infrastructure, skills and equipment that would otherwise be outside the reach of in-dividual companies.[168]

One Catapult sector selected was offshore renewable energy, in which Britain was already the world leader and well-positioned to capture a significant share of a potentially huge global market. In 2014 the UK govern-ment launched the Offshore Renewable Energy (ORE) Catapult in Scotland to promote innovation in offshore wind, wave and tidal energy generation and transmission, with initial government funding of £47 million and a target staff of 120. The new Catapult enjoys the largest concentration of multi-purpose offshore renewable energy technology test and demonstration facilities in the world. It provides access and connectivity, en-gineering and technical expertise to industry and academia.[169] The ORE Catapult has an advisory board of 20 supply chain and utility companies to assist in project selec-tion and decision making, ensuring that proj-ects are directed at themes with commercial potential. An-other advisory body comprised of ten UK universi-ties works with industry to identify cutting edge solu-tions, to help academia access industry expertise, and to assist commercial spinoffs from academia.[170] Recent Catapult projects have included testing of tidal turbines, demonstration of next generation offshore wind turbines, battery storage for offshore wind, and design pro-cesses for tidal turbines.[171]

The ORE Catapult built upon the facilities of an existing research organization, Northumberland's Na-tional Renewable Energy Centre (NAREC), based in Blyth, which was merged with the Catapult in 2014. At the time NA-REC operated world-class research, development and testing facilities for offshore wind, tidal, wave and marine electrical transmission technologies. Incorporation of NAREC was intended to enable it to increase its staffing and "grow the combined business as the sector continues to expand."[172]

IV. Conclusion – Solutions Are Within Reach.

> *We can leverage the know-how and incredible capabilities of Canadians, in order to seize new opportunities and create the jobs of tomorrow right here in Canada. Canadian workers and businesses drive innovation in Canada – particularly dy-namic, growing firms – but with a smaller capital base domestically, they also need a federal partner. Liberals believe Canada can do more to help firms that are working on new ideas and technologies that can be brought to market and create good middle class jobs. We need investments in skills training, public infrastruc-ture, and innovation.*[173]

Budget 2016 begins the process of translating the new government's ideas into actions. The question remains: Is this all that should be done? None of the measures recommended in this paper are beyond reach, nor for the most part do they involve major or even additional expenditure. What is suggested is that a frank assessment be undertaken of the innovation gap that has been inherited, together with a serious examination of how other economies, with whose firms our firms compete, have faced similar challenges. Canada is far from alone in being concerned with innovation. All developed and many developing countries assign enhancing innovation as a very high national priority. There are lessons to be taken on board from experiences of other countries, both from where they have succeeded and where they have failed. Having completed these steps, it will not be that hard to consider what needs to be changed at home and which of the foreign experiences are relevant to addressing Canada's circum-stances. Canadians live in an increasingly interconnected world – a world econo-my that is increasingly rewarding knowledge-intensive goods and services. It is imperative for Canada to adopt measures now for assuring an even more positive outlook for its economy for its firms and workers for decades and generations to come.

Canada enjoys many strong economic fundamentals. It is possible to leverage these advantages into an im-proved innovation ecosystem fully competitive with those of peer countries. But some additional steps will be need to be taken to attain more of Canada's full potential. It is hoped that the suggestions made in this paper stimulate additions to Canada's positive agenda for reform that unleashes Canada's very strong innovation potential and restores economic growth to the Canadian economy.

Enhancing Canadian innovation is a North American imperative. Under NAFTA, Canada, the United States and Mexico are moving toward a single integrated economy, a trend that is most pronounced and observable in technology-intensive sectors like aerospace, electronics, precision instruments and auto-motive products, dynamic industries which contribute more to economic growth than their output and employment figures alone would suggest. All three countries share a growing stake in how these and other high tech sectors perform in international competition. Because North American industries cannot seek to compete globally on the basis of low labor costs, they must pursue knowledge-based compet-itive strategies. North America's integrated high technology industries will remain competitive globally to the extent they can innovate -- applying the best trained and best educated human capital to drive

the systematic application of new technologies in the commercial realm. For North America to succeed, the innovation potential of each country, each state and each province must be fully realized. A more innovative Canada will directly benefit all of North America.

Our conclusion is that it is in our interests in the US and Canada to take every possible step to encourage economic growth and prosperity. We recommend that Canada leverage its strong fundamentals to improve its innovation ecosystem to be fully competitive with peer countries in order to enhance conti-nental competitiveness in the years ahead.

Co-authored by: Tom Howell and Alan Wolff

[1] Liberal Party Platform.

[2] Canadian press accounts highlighted significant deficit spending for the next three years: http://www.theguardian.com/world/2016/mar/22/canada-liberal-budget-deficit-promise-three-times-higher.

[3] "Platform: The global economy is increasingly competitive. With new technologies disrupting old economic models, and emerging economies taking an ever-growing share of the international marketplace, Canada faces both challenges and opportunities." Budget: Managing this demographic shift requires that Canada do more to invest in its next generation, in post-secondary education, and
in training and innovation. The standard of living of all Canadians – not just senior Canadians – relies on it. . . . To strengthen the middle class and deliver more inclusive growth for more Canadians, Budget 2016 makes historic investments in infrastructure and innovation. These investments will both provide immediate help to Canada's middle class and help expand opportunities for those working hard to join it.

[4] Canadians can rightfully claim credit for inventing an astonishing range of products and processes that the rest of the world takes for granted today: the blackberry, the world's first commercial smart phone, Alexander Graham Bell's invention of the hydrofoil, the invention of the snowmobile, the first commercial jetliner in North America, the developer of canola and the McIntosh apple, the place of invention of sonar, insulin, the first practical electron microscope, and the cardiac pacemaker.

[5] Canada leads in areas such as strong and transparent government institutions, leading edge basic science, strong educational sys-tems and institutions, ease of starting a business, and a sound banking system.

[6] CBC News, September 29, 2015

[7] https://www.globalinnovationindex.org/content/page/gii-full-report-2015/#pdfopener.

[8] http://www.conferenceboard.ca/hcp/details/innovation.aspx.

[9] The Conference Board of Canada, 2015.

[10] This refers to triadic patents – patents filed in all of the EU, U.S., and Japan.

[11] https://www.bcgperspectives.com/content/articles/growth-lean-manufacturing-innovation-in-2015/.

[12] "Harper Blames Downturn on Global Trends," Halifax The Chronicle Herald (July 13, 2015); "Tones Economic Projections are All Smoke and Mirrors," The Toronto Star (July 29, 2015).

[13] http://www.tradingeconomics.com/canada/gdp-growth.

[14] "Canada's Unemployment Ticks Up to 7.1% as Business Plan to Add Staff in Coming Months," Financial Post (October 9, 2015).

[15] http://www.tradingeconomics.com/canada/unemployment-rate.

[16] "IMF Cuts Canada's Growth Outlook – Oil Prices Weighing Down Capital Spending," The Hamilton Spectator (October 7, 2015). "IMF downgrades Canada's economic outlook," Toronto Star, January 19, 2016.

[17] Jenkins Report, pp. 2–1.

[18] The 2015 Index ranked Canada 16th, down from 14th in 2012, 12th in 2011, and 10th in 2010.

[19] http://www.conferenceboard.ca/hcp/details/innovation.aspx.

[20] Conference Board of Canada, Who Dimmed the Lights? Canada's Declining Competitiveness Ranking (September 2012) p. 10.

[21] Who Dimmed the Lights? (2012) op. cit., p. 2.

[22] Liberal Party Platform.

[23] Independent Panel on Federal Support to Research and Development, Innovation Canada: A Call to Action (2011), pp. 2–3.

[24] Ibid. pp. 2–6.

[25] The State of Industrial R&D in Canada, The Expert Panel on the State of Industrial R&D in Canada, Council of Canadian Acade-mies, 2013, Table 2.1.

[26] Council of Canadian Academies Expert Panel as Business Innovation, Innovation and Business Strategy: Why Canada Falls Short (2009).

[27] "A Closer Look at Canada's Dismal Report Card – When it Comes to Education, Innovation, the Quality of Life and the Gender Gap, the Country is No Longer Top of its Class," The Toronto Star (July 1, 2015).

[28] Chart presented by John G. Fernald, Federal Reserve Bank of San Francisco, and visiting scholar, the Einaudi Institute for Economics and Finance, a research institute, funded by the Bank of Italy.

[29] Action Plan for Prosperity, co-chaired by the Honourable John P. Manley and Paul Lucas. Oct. 2010.

[30] Canada's Research-Based Pharmaceutical Companies, 2015 Pre-Budget Submission, House of Commons Standing Committee on Finance (Ottawa, August 6, 2014).

[31] Dawson Strategic, Slow and Steady Will Not Win This Race: Trade Negotiations, IP Protections and Canada's Pharmaceutical In-dustry (May 2015) p. 10.

[38] Ibid. pp. 1, 7, 8.

[39] The Hauser Report, directed by entrepreneur Hermann Hauser, involved study of intermediate research organizations in a number of countries. Although the Labour government stepped down in May 2010 before Hauser's recommendations could be acted upon, the Coalition government which followed implemented the recommendations in their essentials, creating a national network of Technology and Innovation Centres (TICs) largely based on redirection of existing resources. Hermann Hauser, The Current and Future Role of Technology and Innovation Centres in the UK (March 2010).

[40] http://www.instituts-carrot.edu/en/instiuts-carrot; Jean-Michel Le Roux, Carrot Program (2012).

[41] Rising to the Challenge is available online at http://www.nap.edu/catalog/13386/rising-to-the-challenge-us-innovation-policy-for-the-global.

[42] The last of these, Research, Innovation and Technological Progress in Germany, 2016, is available at http://www.e-fi.de/fileadmin/Gutachten_2016/EFI_Executive_Summary_2016.pdf. See also, Meeting Global Challenges: U.S.-German Innovation Policy: Summary of a Symposium (2012), National Academies Press.

[43] "Shift in Canadian National Research Council's Emphasis Ignites Controversy," Physical Today (May 17, 2013); "Dispute Over the Fu-ture of Basic Research in Canada," The New York Times (February 16, 2014).

[44] Innovation Canada (2011) op. cit., pp. 7-7.

[45] "Shift in Canadian National Research Council's Emphasis Ignites Controversy," Physics Today (May 17, 2013).

[46] "Dispute Over the Future of Basic Research in Canada," The New York Times (February 17, 2013).

[47] "Ottawa Tells Research Council to Move Away from Basic Science," Waterloo Region Record (May 8, 2013).

[48] "Cutting Away at the NRC's Research Capability," CCN Matthews (December 5, 2013).

[49] See generally Suzanne Berger, Making in America: From Innovation to Market (Cambridge, MA and London: MIT Press, 2013) p. 58.

[50] Examples include pre-eminent U.S. National Laboratories such as Sandia, Oak Ridge, Lawrence Livermore and Brookhaven; Germa-ny's Max Planck Gesellschaft; the National Center for Scientific Research (CNRS) in France. A 2008 Canadian comparison of the U.S. and Canadian research systems observed that "a U.S. laboratory such as Oak Ridge competes with the best universities in the world in material science, as measured by research output in leading scientific journals" Ilse Treurnicht, "University Research and Industrial Innovation: How Can Canada Compete and Win? Choices (October 2008).
51 http://www.globalinnovation/ex.org/content/page/gii-full-report-2015/#pdfopener.

[52] Jenkins Report (2011) op. cit., pp. 2–15.

[53] Donald McFetridge, "The Canadian System of Industrial Innovation," in Richard R. Nelson (ed.), National Systems of Innovation: A Comparative Analysis (Oxford and New York: Oxford University Press, 1993) p. 305.

[54] Jenkins Report (2011) op. cit., pp. 2–16.

[55] Annalee Saxenian, Regional Advantage: Culture and Competition in Silicon Valley and Route 128 (Cambridge, MA: Harvard Univer-sity Press, 1994); Timothy J. Sturgeon, "How Silicon Valley Came to Be," in Martin Kenney (ed.) Understanding Silicon Valley (Stanford, CA: Stanford University Press, 2000); Albert N. Link, A Generosity of Spirit: The Early History of Silicon Valley (Research Triangle Park: Research Foundation of North Carolina, 2005).

[56] Andrea Mina, David Connell and Alan Hughes, Models of Technology, Development in Intermediate Research Organizations (Cam-bridge: University of Cambridge Center for Business Research, December 2009) Working Paper No. 396, p. 3; In Britain, "the university and the business and industrial community have always treat[ed] each other with indifference, if not with distrust and hostility". Alfred Chandler, Scale and Scope: The Dynamics of Industrial Capitalism (Cambridge, MA: Harvard University Press, 1990) p. 293.

[57] Blanka Vavakova, "Reconceptualizing Innovation Policy: The Case of France," Technovations (2006) p. 445.

[58] European Commission, Erawatch Country Reports 2011: France, p. 13.

[59] Aaron L. Friedberg, The Weary Titan: Britain and the Experience of Relative Industrial Decline 1895-1905 (Princeton: Princeton Univer-sity Press, 1988); Corelli Barnett, The Collapse of British Power (Atlantic Highland, NJ: Humanities Press International, 1972) Written Evi-dence Submitted by Coalition of British Industries (TIC 34), House of Commons Science and Technology Committee, January 12, 2011.

[60] Chandler, Scale and Scope (1990) op. cit.

[61] In the mid-1700s, a number of German apothecaries who manufactured medicines gained access to universities because "apoth-ecaries and other artisans . . . possessed useful knowledge and technical expertise". Andreas Sigismund Marggraf (1709–1782) an apprenticed apothecary with no university degree was appointed (at the urging of the Prussian government) director of the Berlin Academy of Sciences in 1753 and director of its Physical Class in 1760. He was one of many apprenticed and practicing apothecaries who gained university appointments in chemistry. A cultural gap which might otherwise have emerged between the business of com-pounding medicine and the academic discipline of chemistry was avoided "because latent energies in the pharmacological profession were released by state intervention in recruitment" for the universities. Karl Hufbauer, The Formation of the German Chemical Commu-nity (1720-1795) (Berkeley: University of California Press), p. 55; Ursula Klein, "Apothecary's Shops, Laboratories and Chemical Manu-facture in Eighteenth Century Germany," in Lissa Roberts, Simon Schaffer et al., (eds.), The Mindful Hand: Inquiry and Invention From the Late Renaissance to Early Industrialization (Amsterdam: Royal Netherlands Academy of Arts and Sciences, 2007) pp. 247–48.

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[63] Christian Hamburg, Structure and Dynamics of the German Mittelstand (Heidelberg and New York, Physi-ra-Verlag, 1999) pp. 58–59; Alan D. Beyerchen, "Trends in the Twentieth Century German Enterprise," in The Academic Research Enterprise Within the Industrialized Nations: Comparative Perspectives (Washington, D.C.: The National Academies Press, 1990) p. 80.

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[65] Berud Venor and Klaus E. Meyer, The German Miracle Keeps on Running: How Germany's Hidden Champions Stay Ahead in the Global Economy (Berlin: Berlin School of Economics, 2007).

[66] Hal Hansen, "Rethinking the Role of Artisans in Modern German Develop ment," Central European History (2009) p. 36.

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[69] By 1900, Prussia and Saxony alone had over 300 technical institutes, Diego Comin, Gunnar Trumbull and Kerry Young, Fraunhofer: Innovation in Germany (Harvard Business School Monograph, 2012) p. 3.

[70] Canadian Foundation for Innovation, Conference on Innovation and Commercialization of University Research: Perspectives on Inno-vation (February 2002), p. 12.

[71] Tom Brzustowski, Why We Need More Innovation in Canada and What We Must Do to Get It (Ottawa: Invenire Books, 2012) p. 247.

[72] "National Research Council Move Shifts Fed's Science Role," CBC (May 7, 2013).

[73] Invest $200 million per year, in each of the next three years, in a new innovation agenda. We will provide direct support to business incubators and accelerators, research facilities, financing, and other support for successful small companies wanting to grow and export. The objective is to create successful networks like the American and German partnerships between businesses, government, and univer-sity and college research. Working with provinces, post-secondary institutions, and industry, this funding will also help modernize and strengthen the technology transfer and commercialization functions at universities and colleges. Liberal Party Platform.

[74] For a case study, see National Research Council, 21st Century Manufacturing (2013) op. cit., pp. 354-57.

[75] Peter Howitt, From Curiosity to Wealth Creation: How University Research Can Boost Economic Growth (C.D. Howe Insti-tute, June 2013) p. 18.

[76] John A. Mathews and Mei-Chin Hu, "Enhancing the Role of Universities in Building National Innovative Capabilities in Asia: The Case of Taiwan," World Development (Vol. 35 No. 6, 2007) p. 1012; "Hsinohu Science Park, A Bastian for Growth, Innovation, and Clus-ter-Based Industries," China Post (December 15, 2010).

[77] National Research Council (U.S.) 21st Century Manufacturing (2013) op. cit., pp. 304-06.

[78] National Research Council (U.S.), 21st Century Manufacturing (2013) op. cit., pp. 224-84.

[79] Fraunhofer ILT Annual Report (2012), p. 20; "Germany Opens Nanoelectronics Center in Dresden," Deutsche Presse Agentur (May 31, 2005).

[80] ITRI spinoffs include TSMC, the largest semiconductor foundry in the world; the semiconductor firms Winbond, Vanguard, and UMC; Taiwan Mask Corporation, and maker of integrated circuit mask designs; the solar cell maker DelPoint, and Phison Electronics Corp., are one of the world's leading makers of flash memory systems.

[81] "ITRI Pushes Technology Sector to New Frontier of Innovation," Taiwan Journal (October 19, 2007).

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[84] House of Commons, Committee on Science and Technology, Second Report: Technology and Innovation Centres (February 9, 2011) p. 7.

[85] Christian Hamburg, Structure and Dynamic of the German Mittelstand (Heidelberg and New York: Physica – Verlag, 1999) p. 1. Volker Treier, the chief economist of the German Chamber of Commerce, characterizes the Mittelstand as the backbone of the Germany economy. Volker Trier, "The Engine of Growth," Wall Street Journal (June 26, 2011).

[86] Hamburg, German Mittelstand (1999) pp. 58-59.

[87] National Research Council (U.S.) 21st Century Manufacturing: The Role of The Manufacturing Extension Partnership Program (Wash-ington, D.C.: The National Academies Press, 2013) pp. 153–54.

[88] Support from an IRAP Advisor enabled the Canadian company Borreal Laser Inc., a maker of laser-based trace gas analyzers for detection of hazardous gases, to double its sales, move from an analog to a digital platform, establish clients in 45 countries, as to double its work force from 7 to 15 employees. NRC, "Local Digital and Growth-Oriented" (2012) http://www.nrc.cnrc.rc.cal/eug/irap/success/2012/boreal_laser_inc_trace_gase_analzer.html

[89] National Research Council (U.S.) 21st Century Manufacturing (2013) op. cit., pp. 222–23.

[90] An Action Plan for Prosperity, Coalition for Action on Innovation in Canada, co-chaired by the Honourable John P. Manley and Paul Lucas.

[91] http://www.gazette.gc.ca/rp-pr/p1/2015/2015-05-02/html/reg3-eng.php.

[92] As two Canadian intellectual property lawyers noted in 2015, "[T]he application of the promise doctrine may create some uncertainty for the Canadian patent landscape". Mark D. Penner and Richard Y. Cheung, "Increased Utility Requirements in Canada? How the Promise Doctrine has Challenged Patentees and What Can Be Done to Address These Challenges," Lawyer Issue (July 3, 2015).

[93] The case of Pfizer Canada Inc. v. Apotex, 2011 FCA 236 illustrates the problem caused by the "promise doctrine".... The drug in question was used for the treatment of glaucoma. No long term tests had been conducted as of the filing date – indeed, how could they be? The promise doctrine creates a sort of Catch-22: File late and have one's intellectual property misappropriated while the drug is going through extensive trials, or file early and have a court come along well after the issuance of a patent deemed for years to be valid and destroy the intellectual property right. For example, in the case cited above, Pfizer Canada's patent on Xalatan was issued in 1994 and ruled invalid by an appellate court in 2011, 17 years later.

[94] In 2012, a Federal Circuit invalidated a patent for helicopter landing gear held by Eurocopter, a helicopter manufacturer. Eurocop-ter's patent identified a number of shortcomings in the prior art, and promised that the new technology would correct them. The Court ruled that the promise was not only a functioning helicopter landing gear, but improvements in prior art landing gear. The Court ruled against Eurocopter on the grounds that with one exception, its new landing gear had failed to meet its promises. Eurocopter v. Bell Helicopter Textron Canada Limitee, 2012 FC 113, affirmed 2013 FCA 219.

[95] See Defining the Difference: What Makes Biologics Unique; National Library of Medicine, National Institutes of Health, at http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3564302; and PhRMA Report 2013 Medicines in Development – Biologics at http://www. phrma.org/sites/default/files/pdf/biologics2013.pdf. A recent report by Canada's Department of Foreign affairs observed that "To-ronto has the largest faculty of medicine in North America, producing more peer-reviewed publications than any other medical centre in the world; Canada's health sciences research community includes over 30,000 investigators in 16 medical schools and over 100 teaching hospitals and research institutes". "Error or Folly? The Sorry State of Basic Research Development in Canada," Biotechnology Focus (January 9, 2015).

[96] "Merck Canada to Enter New Area of Medicine and Biosimilars in Canada," Canada Newswire (December 3, 2015).

[97] Genome Canada invested over $700 million across Canada, leveraging an additional $1.5 billion in investments in 115 R&D projects. http://www.ic.gc.ca/eic/site/lsg-pdsv.nsf/eng/hn01768.html.

[98] Government of Canada, Life Sciences Industries: Canada's Pharmaceutical Industry and Prospects, http://www.ic.gc.caleic/site/lsg-pdsv.nsf/eng/hn01768.html; "Canada Needs a Strategy to Reach its Biotech Potential," Biotechnology Focus (November 5, 2015).

[99] Government of Canada, Industry Canada, International Patent Strategies for Biopharmaceutical Small and Medium-sized Enterprises (SMEs) in Canada http://www.ic.gc.ca/eic/site/lsg-pdsv.nsf/eng/hn01763.html#-sub2.

[100] Ibid.

[101] Biologics Lift for UK, at http://www.pharmafile.com/news/184897/biologics-lift-uk.

[102] Building a World-Class Innovative Therapeutic Biologics Industry in China, accessed at https://www.bio.org/sites/default/files/BIO_ RDAC_Biologics_White_Paper_Jan_2013.pdf.

[103] NDP Analytics (February 2014): A World Bank study finds that a 20 percent increase in the number of patents granted annually was associated with a 3.8 percent increase in the output of 92 countries during 1960-2000. . . . An OECD report finds that a 1 percent change in the strength of a country's IP protection framework is associated with a 2.8 percent increase in FDI inflows and a 0.7 percent increase in domestic R&D. . . . [H]igher levels of IP protection attract a greater amount of FDI in IP-intensive industries than in non-IP-in-tensive industries. For example, U.S. FDI in foreign chemical industries (an IP-intensive industry) is 3.7 times greater than average FDI in foreign manufacturing overall.

[104] http://www.canadiangenerics.ca/eu/resources/if.brandsvsgeneric.asp.

[105] Council of Canadian Academies, Innovation and Business Strategy (2012) op. cit., p. 183.

[106] Most blockbuster drugs that fueled Big Pharma profits in the last two decades went off patent in the past few years, opening the market to generic copies. Governments and insurers in Canada have pushed for lower and lower prices on the copies, and often require that the patients' prescriptions be filled with generics. "Off-shore Generic Drugs Save Money, But At What Cost?" Vancouver Sun (March 14, 2015).

[107] Ibid. "Drug companies are increasingly moving production overseas where labor is cheap. As much as 20 percent of the drugs Canadians consume are made in countries such as India and China". "Companies Knew Drugs They Sold Were Defective," The Toronto Star (September 11, 2014).

[108] "Health Canada Mum on Overseas Drug Plant Inspections: Expert," CTV News (September 10, 2012).

[109] The Canadian generics maker Apotex reportedly sources drug ingredients and finished drugs from three factories in Bangalore, India. In 2014 U.S. FDA inspectors "uncovered blatant and repeated problems at one of the plants". The U.S. inspectors reportedly watched as an Apotex quality control microbiologist wrote over documents detailing a bacterial contamination test "using a black

marker in order to appear that a growth promotion testing had been performed" at an earlier date. Inspectors found that 500 power outages over the course of a year could have impaired the quality testing of drugs. Employees testing drugs which yielded the result "unknown impurities" continued to retest the drugs and did not report the adverse results. Such practices had continued despite a 2013 FDA inspection which had uncovered similar data rigging. University of Ottawa law professor Amir Attaran comments that "The crux is this: India is supplying Canada with medicines that the United States knows are adulterated. They are available in your pharma-cies for you". "Companies Knew Drugs They Sold Were Defective," The Toronto Star (September 11, 2014).

[110] United States Constitution, Article I, Section 8.

[111] Abraham Lincoln summarized the role played by patents in promoting innovation during this era: "Before [patents] any man [could] instantly use what another had invented; so that the inventor had no special advantage from his own invention. The patent system changed this; secured to the inventor, for a limited time, the exclusive use of his invention; and thereby added the fuel of interest to the fire of genius, in the discovery and production of new and useful things."

[112] Anthony Williams, Governing Innovation Commons: Private Ordering of Intellectual Property Rights (Working Paper, Department of Government, Lincoln School of Economics, March 2005).

[113] Justice William O. Douglas in Jungerson v. Ostby & Barton Co. 336 U.S. 560,772 (1949).

[114] Deputy Assistant Attorney General Bruce B. Wilson, "Patent and Know-How-License Agreements, Field of Use, Territorial, Price and Quantity Restrictions," Remarks before the Fourth New England Antitrust Conference 19 (November 6, 1970).

[115] Richard Hofstadter, "What Happened to the Antitrust Movement? Notes on the Evolution of an American Creed," in Richard Hof-stadter (ed.), The Paranoid Style in American Politics (London, 1966), pp. 96, 135.

[116] Federal Trade Commission, To Promote Innovation: The Proper Balance of Competition and Patent Law and Policy (October 2003).

[117] Advisory Committee on Industrial Innovation, Industrial Subcommittee for Patent and Information Policy, Report on Patent Policy ISS (1979).

[118] Abbot B. Lipsky, "Current Antitrust Division Views on Patent Licensing Practices," 50 Antitrust Law Journal 515 (1981 82). See generally F.M. Scherer, "The Political Economy of Patent Reform in the United States," Journal on Telecommunications and High Tech-nology Law 7:180 (2008).

[119] "Innovation's Golden Game," The Economist (December 12, 2002). See also David C. Mowery and Bhaven N. Sampost, "The Bayh-Dole Act of 1980 and University-Industry Technology Transfer: A Model for Other OECD Countries?" The Journal of Technology Transfer (30 (1-2) 115–127 (2004).

[120] In the years that preceded and immediately followed enactment of Bayh-Dole in 1980, an average of 1.3 U.S. university technology transfer offices opened each year. In the years 1983 to 1995 the annual average increased dramatically to 7.4 new offices. Naomi Hausman, University Innovation and Local Economic Growth and Entrepreneurship (Harvard Center for Economic Studies, CES-12-10, June, 2012) citing Association of University Technology Managers Licensing Activity Study (2004).

[121] Association of University Technology Managers, Annual Licensing Surveys.

[122] Hausman (2012) op. cit., pp. 2–3. An illustrative example is the University of Colorado, which in the wake of Bayh-Dole restructured and strengthened its technology transfer activities. By 2006 over 60 companies had been launched using federally-funded technolo-gies developed at the university, and the majority of these new firms remained in nearby Boulder and Broomfield Counties. "Stewards of Innovation: CU's Technology Transfer Office Helps Ideas Become Companies," Boulder The Daily Camera (June 19, 2006).

[123] http://www.dtic.mil/ndia/2009smallbusiness/bankit.pdf.

[124] Diamond v. Chakrabarty, 447 U.S. 303 (1980); Diamond v. Diehr, 450 U.S. 175 (1981).

[125] Williams, Governing the Innovation Commons (2005) op. cit., p. 6.

[126] Statement of Robert P. Taylor, Section of Intellectual Property Law, American Bar Association, Competition and Intellectual Property Law and Policy in the Knowledge-Based Economy (Hearings of Federal Trade Commission and U.S. Department of Justice, July 11, 2002).

[127] William Blumenthal, Government Policy for Fostering Innovation (Remarks Before the China Council for the Promotion of In-ternational Trade and U.S. Chamber of Commerce, Global Forum and Intellectual Property Rights Protection and Innovation, Bei-jing, March 28, 2007).

[128] National Research Council, Rising to the Challenge: U.S. Innovation Policy for the Global Economy (Washington, D.C.: The National Academies Press, 2012), pp. 405-406.

[129] Battelle Technology Partnership Practice, The U.S. Biopharmaceuticals Sector: Economic Contribution to the Nation (2011).

[130] Ross DeVol, Armin Bedroussian, and Benjamin Yeo, The Global Biomedical Industry: Preserving U.S. Leadership (Milken Institute, 2011), p. 19.

[131] William Blumenthal, Government Policy for Fostering Innovation (Remarks Before the China Council for the Promotion of In-ternational Trade and U.S. Chamber of Commerce, Global Forum and Intellectual Property Rights Protection and Innovation, Bei-jing, March 28, 2007).

[132] The National Research Council of Canada (the largest research funding entity) and the Centre of de Recherché Industrielle du Québec retain ownership and negotiate licenses. The National Sciences and Engineering Research Council of Canada and the Fonds de la Recherché en Santé du Québec allow transfer to patent ownership. "Bayh-Dole 30 Years Old – Must the Government Remain the Owner of Patents Obtained as the Result of its Subsidies? ROBIC Newsletter (2015).

[133] Cited in "Getting University IP to Market: How Canada Falls Short," Francis-Moran.com (August 2, 2011).

[134] Jenkins Report (2011) op. cit., pp. 7-11.

[135] Ibid. pp. 7–11 – 7–17.

[136] Council for Canadian Academies, Innovation and Business Strategy (2009) op. cit., p. 125.

[137] "High Impact Firms Key to Improving Canadian Competitiveness: BDC Study," (Canada Newswire (May 27, 2015).

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[139] "It's Time to Upgrade our 'Mediocre' Economy," The Toronto Star (October 14, 2015).

[140] "Small Businesses Need Access to Capital to Grow," Waterloo Chronicle (October 7, 2015.

[141] Jorge Niosi, "Bridging Canadian Technology SMEs Over the Valley of Death" International Productivity Monitor (Spring 2009).

[142] Qualcomm Inc. Annual Report filed with the Securities and Exchange Commission for the year ending September 2014, at http://investor.qualcomm.com/secfiling cfm?filingID=1234452-14-320&CIK=804328#QCOM10-K2014_HTMS5E895A 74318C59392424C8ED7FAFEFFE.

[143] Source: U.S. Small Business Administration. SBA SBIR/STTR Overview, October 2015.

[144] http://www.pionline.com/article/20140121/ONLINE/140129969/fund-of-funds-launched-for-canadian-venture-cap-program.

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[154] Clean Energy Canada, Tracking The Energy Revolution (2015) p. 5.

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