Johnson-Shoyama Graduate School of Public Policy
University of Saskatchewan
101 Diefenbaker Place
Saskatoon, SK, S7N 5B8
Canada

February 17, 2011

Expert Review Panel on Research and Development
1200-270 Albert Street
Ottawa, Ontario, K1A 5G8.

Via: consultations@rdreview-examenrd.ca

Re:Submission to the Expert Review Panel

Please find attached a brief produced on behalf of the scholars and researchers involved in VALGEN, a four-year $5.4 million, stand-alone GE^{3}LS (genomics, ethics, environment, economics, law and society) project under the Genome Canada Applied Genomics for Bioproducts and Crops Competition. The team includes researchers from the Universities of British Columbia, Calgary, Saskatchewan, Regina, Ottawa, McGill, Laval, University of Edinburgh and Université de Versailles Saint-Quentin-en-Yvelines. VALGEN(Value Addition Through Genomics and GE^{3}LS) is supported by Genome Canada and managed by Genome Prairie. Major funding partners include the Government of Saskatchewan, Western Economic Diversification, Genome Alberta, Genome BC, Genome Quebec, the Canola Council of Canada and SRC Holdings Ltd.

The VALGEN team is investigating how Canada and the rest of the world can benefit from applications of agricultural genomics, the science of the entire set of genes making up a particular organism such as our familiar crops of wheat, canola, flax and corn/maize. VALGEN focuses on three crucial factors that affect how scientific discoveries make their way from laboratory to the marketplace: democratic engagement, intellectual property, and regulation and governance. These research themes are strengthened by research and development of new models, methods and metrics to capture the effects of innovation and combined with foresighting activities to envision future pathways.

On behalf of the research team, we offer based on our recent work some observations on the theoretical foundations, practical implementation and conceptual framing of Canada's science and innovation policy.

Sincerely,

Dr. David Castle
Chair of Innovation in the Life Sciences
ESRC Innogen Centre
University of Edinburgh

Dr. Peter Phillips
Professor of Public Policy
Johnson-Shoyama Policy School
University of Saskatchewan

Submission to Expert Review Panel on R&D

Abstract:

Science and technology led innovation is often posited as the driving force behind 21st century economies. Canada differs from many other OECD countries in that government (especially the federal government) is a relatively large investor and funder in science and technology, investing heavily in basic and early applied research (either through grants and funding for post-secondary education and research, for infrastructure projects, through special operating agencies such as Genome Canada, through intramural research and to firms through tax expenditures).

In spite of the investments, Canada has, compared to other OECD countries, poor productivity growth. Answers to this mysterious gap between inputs and outputs may be found in the theoretical foundations, the practical implementation and the conceptual framing of the government's science and innovation policy.

1. Theoretical foundations (Drawing on Phillips and Castle 2010)

Underlying the current federal policy is the assumption that government incentives reduce market entry and operating barriers otherwisefaced by the private sector. Crucial to this point of view, and perhaps its central weakness, is that the private sector will respond to these incentivesby investing in research, development and commercialization, essentially turning inventions and discoveries into innovations (i.e. products, services and organisational structures that bring benefit to Canadians). The economic theory of technological change has for many years focused on the firm as the primary research unit (e.g. Nobel Prize winning economists Kenneth Arrow and Robert Solow) and, in the footsteps of Joseph Schumpeter, has examined the microeconomic incentives and impacts of private research and commercialization. More recently, economists have examined the role of firms in "endogenously" generating innovation through planned, systematic effort to add value through research and development. This is generally modeled as a rational linear process where basic research leads successively to applied research, development, commercialization, use and benefit. The policy challenge, however, is that the outputs from the research and development phases are usually non-rival and non-excludable ideas, recipes or business models. Without some intervention by government (as either incentives or other practical support), investors are unlikely to invest optimally in these stages as they cannot be certain of recouping the costs of their investments through commercialization and use of the resulting invention.

Much of the federal government's S&T policy and programming fits with this firm-centric view of innovation. The federal support for strong intellectual property (IP) protection through patents, industrial trade secrets and other IP mechanisms is a major instrument in the nation's innovation policy. In addition, government funding and performance for primary and applied research in public labs, combined with generous tax incentives for private sector R&D and extensive grants and contributions for scientific and research activities in universities, are attempts to provide incentives for individuals and entrepreneurs to undertake research activities and adapt and adopt technology that will lead to economic and social innovation.

As an alternative to firm-centric approaches, political economists and sociologists have developeda range of theoretical "systems" approaches to innovation. They argue that innovation is a diffuse process, where no single firm or region can truly be viewed as self-sufficient or self-sustaining. Economists Stephen Kline and Nathan Rosenberg explicitly identify the potential for open research systems in their 'chain-link model of innovation', which begins with a basically linear process moving from potential market to invention, design, adaptation and adoption but adds feedback loops from each stage to previous stages and the potential for the innovator to seek out existing knowledge or to undertake or commission research to solve problems in the innovation process (Phillips 2007 offers a complementary vision of innovation as a knowledge-management cycle).

This dynamic process has been variously modeled as a regional innovation system, an industrial cluster or a triple helix of governments, universities and firms. Michael Gibbons and a number of colleagues posit that two modes of knowledge generation flow from such systems. Mode 1 knowledge, which they call traditional knowledge, is generated within disciplinary, primarily cognitive, contexts and generally commercialized through the linear, firm centric innovation system. Mode 2 knowledge, which is created in broader 'transdisciplinary' social and economic dynamic systems,

creates a profound challenge to the traditional governing system because communications tends increasingly to take place across institutional boundaries and not simply within established hierarchies. This conception of innovation suggests that policy needs both to remove barriers to and create incentives for these dynamic systems to develop and operate.

2. Worrying trends (drawing on Castle and Phillips Forthcoming 2011)

Aggregatedindicatorsforscience, research and development mask some important features of Canada'srelative performance in S&T-related R&D. Canada has about 20% more researchers per capita than the OECD average (but about 20% fewer than the US) and publishes approximately 4.5% of all basic research in academic journals, yet at the same time the cost of each scientific publication is above OECD average (OECD, 2010). Conventional wisdom says if there is a strong science and technology R&D base acting as an "ideas pump" into the economy, wealth and prosperity should flow. The difficulty is that is not occurring. Productivity is lagging both expectations and key comparator countries (Castle and Phillips, 2011).

The fundamental challenge is that the lack of higher productivityerodes Canada's foundation for a rising standard of living. The OECD data for 2009 shows that the average Canadian works about 8% longer than an American, harder than the OECD average (almost 13% more than the average for the OECD), and more than all of our key comparator countries. Despite this extra effort, we generate a GDP per capita that is about 19% below the US average and barely equal to the average of the OECD countries.

Meanwhile, the federal government continues to ring-fence its spending by narrowing its interpretation of federal responsibility. The government has signalled, in thehealth and higher education sectors, that where provincial jurisdiction applies the federal government can be expected to observe constitutional arrangements—that is, federal agencies will retreat from spending in those areas. Provinces wishing to increase S&T and R&D therefore face this challenge alone and do so with varying results. Provincial attempts to fill the gap are uneven because of the significant inequalities in their fiscal and R&D capacity. National gross domestic expenditures on research and development (GERD) peaked in 2001 at 2.09%, held steady until 2006, but thereafter dropped to an average of 1.92 from 2007-09 (and as low as 1.87% in 2008) (Statistics Canada 2010a). By province in 2008, the last year for which there is reported expenditure data, the range was 0.81 for Saskatchewan to 2.61 for Quebec, and only Ontario and Quebec were above the national average of 1.87, which translates to per capita expenditure of $1080 and $1023 respectively (Statistics Canada 2010b). By performing sector, Ontario tends to do better than other provinces (64%) because the province includes the majority of the federal labs and because of the concentration of Canada's industrial GERD. Alberta and Saskatchewan maintain relatively high levels of provincial funding compared to their total GERD. In Quebec, Ontario and Alberta the private sector contribution hovers around 50%, much higher than in Atlantic Canada.

When these events are considered in light of the innovation gap and potential productivity trap, the trajectory does not look good for Canadian prosperity.

3. A different set of questions (drawing on Phillips and Castle 2010)

Most individuals and groups involved in science, technology and innovation policy agree that Canada can and should do better in terms of innovation. Many studies critical of Canadian science and technology innovation have focused on different problems within the innovation system and its implications for productivity (Conference Board of Canada 2008), global competiveness (Industry Canada 2008), drivers of commercialization (Industry Canada 2006), and the productivity gap (STIC 2009 and Council of Canadian Academies 2009). These and other studies conclude that Canada invests heavily in science and technology, but does not have a well-coordinated governance system to efficiently and effectively commercialize and use technologies in a timely and sustainable manner.

The current federal strategy (and most predecessor plans) asserts that federal effort and complementary action by provinces, universities and industries should focus on expanding entrepreneurial activity, strategically directing

research to some specific, high impact areas and increase the supply of high quality personnel — otherwise called skilled and experienced workers (Government of Canada 2007). In short, the strategy seeks to link strong minds and new or innovative ideas through private and entrepreneurial action. Overall, there is a focus on research excellence as the key goal of the plan.

While this sounds on first hearing to be a plausible approach, it suffers upon further reflection. In the first instance, we may not need a "science and technology" strategy — rather, we may need an innovation agenda or strategy. The Federal strategy, largely confirmed by the Conference Board Report Card, notes that Canada has a strong basic science, technology and research capacity—concentrated in a number of relatively well-networked, strategic, cutting-edge areas, as assessed by the Council of Canadian Academies.

Where we face difficulties is getting that knowledge into use in Canada. The federal benchmarking here is more problematic. It shows that Canada appears to be somewhat weaker in terms of the skills and talents of our workforce — we have the largest portion of our population with tertiary education but rank below average in our share of the population with either PhDs or natural science and engineering degrees— and that our public sector and universities contribute a relatively larger portion of R&D in Canada than in most other OECD countries.

The implication is that private activity is somehow weak or ineffectual, an implication borne out by private sector investment in R&D thathas plateaued. In essence, one might conclude that the basic problem in Canada is not about how much (or even how) Ottawa spends on S&T. What is at issue is what Canada ought to do with the science and technology that is either languishing in public laboratories and universities or that is unceremoniously pushed out to an unwilling or incapable private sector. If this is the root of the productivity gap, then Ottawa is unlikely to be able to spend its way out of this private sector problem.

An investigation of federal activities offers a tantalizing glimpse of the issue, but it is far from clear how federal efforts can overcome private sector weakness. Before governments invest, they should at least be clear about whether they are addressing the symptoms or a set of underlying problems.

One way to look at the problem would be to examine how Canada differs from the US. Canada appears to be relatively well endowed with good science, to have many of the same industries and firms as the US, to have a labour force that is as well or better trained than that of theUS and to have as many entrepreneurs per capita as in the US. Most of the implementation measures presented by the federal S&T strategy do not explain the gap but merely further define the scope of the gap.

One possibility is that the heavy reliance on indirect support in Canada relative to that in the US and other international comparators may simply amplify Canada'sdisconnect between the world-class science and industrial uptake and use. This would be relatively straightforward to address.

There may be two further fundamental differences between Canada and the US that could contribute to Canada's relatively poor innovation performance and are not addressed by the current federal strategy.

First, Canada simply lacks the scale of the US. Recent research indicates that value added per employed person rises as the population of a local economy rises. The underlying logic is that larger centres offer bigger, more sophisticated markets that can allow land, labour, capital and ideas to be employed in their best uses. This makes intuitive sense. If a lawyer, for instance, is trained and experienced in intellectual property law for biotechnology, he or shewould likely make more money if able to solely practice in that field. If the local market is too small to allow for full specialisation, then the lawyer will be forced to offer less differentiated services that will earn less. The effect of scale is significant. A recent survey of the literature (Venables, 2006) showed that doubling any city's size will increase productivity between 3% and 8%. Thus moving from cities of 50,000 (e.g. Cornwall or Shawinigan) to 200,000 (e.g. Regina or Saskatoon) would increase productivity between 9% and 24%. Increasing to one million (e.g. urban Ottawa, Calgary or Edmonton) would raise productivity by 15% to 40%. Cities the size of Toronto (>5 million) would have productivity about 50% higher than those of cities of 50,000. Overall, approximately 45% of our population lives in million plus cities, compared with 53% of the US population. And our larger cities are smaller. New York and LA, with 18 and 12 million population each, dwarf Toronto, Montreal and Vancouver. While Canada cannot and probably does not want to become just like the US, federal policy should not exacerbate the challenges of small market size. Currently

federal development policies and provincial and municipal strategies create barriers or provide incentives that artificially subdivide our economic sectors. While economic development is appropriate, it should be used to build on areas of strength and not myopically spread the wealth around in ways thatundercuts economies of scale.

Second, research excellence is not a direct guarantee of commercial and economic development. The evidence is in – Canada does high quality research without productivity gains. Yet the best ideas or products are not assured of surviving and thriving because Canada tends to lumber where it needs to be fleet of foot. Easily the least adaptable and flexible actor is the Canadian regulatory system that tries to 'manage innovation' in a rational way. But 'management of innovation' is an oxymoron because innovation by nature is chaotic and unpredictable. It only truly thrives where there are competing models, competing structures, competing ideas, competing investments and competing organizations. Those who interact with Canadian regulatory or development agencies assert that that decision-making processes are slow, overlapping and sometimes inconsistent. Canadian governments are focused on excellence and accountability rather than speed, adaptability and effectiveness. One structural factor that contributes to this is that federal, provincial and municipal governments tend to want to work together — costs rise and innovation slows as agencies attempt to coordinate and collaborate on far too many activities.

In contrast, the US has more of a distributed system, where different governments sometimes do complementary but more often do competing things, often without reference to other levels of government. Moreover, the US has strong proponents for action — while state governments tend to be relatively weaker than Canadian provinces, the combination in the US of relatively strong and independently-minded municipalities using funds raised locally and aggressive private venture capital corporations are a hallmark of the American model. What distinguishes these actors is their decisiveness — they act and react quickly and effectively.

If the root of the Canada-US productivity gap is scale and governance, then the Canadian strategy of supporting S&T, education and entrepreneurship may not make much of a difference. Ultimately, governments may need to look to their own structures, and create conditions that will reduce the burdens of scale and over-governance. Theory and evidence suggests three possible policy responses.

First, governments need to create the room to innovate and try new things. Canada does not have that in many regions and sectors. Canadian governments frequently set rules that require single solutions to complex and differentiated problems — either at the community, provincial, regional or national level. Monopoly solutions often strangle innovation. A particular problem is that rational decisions are made by higher orders of government to nurture, develop and support strategic initiatives. Some of these work very well, but oftentimes the lessons and models are then inappropriately applied to other areas. The result is the short-term, realizable innovations that will generate immediate payoffs are foregone in hopes of a big win down the road. Our policies need more balance between assisting firms to pursue small, immediate and realizable gains and large-scale efforts to create long-term structural change.

Second, innovation needs the right reward structures. Too often governments spend a disproportionate amount of time worrying about losers from change, and seeking ways to tax winners and subsidize those losers. While some redistribution may be necessary, it should not be the only or even the prime focus. Almost every new product, technology, process, organization and market will undercut somebody else's value. If the winners in Canada always have to compensate the losers, then fewer truly novel innovations will be tried here first. Experience shows that the biggest gains from innovation accrue to early adopters — if they are discouraged from acting in Canada, the benefits will be lost.

Third, Canadian policy needs to be more tolerant of failure. Innovation inevitably delivers many failed experiments. Currently municipalities, provinces and the federal government spend an inordinate amount of time, energy and financial capital trying to prevent failure, or if it happens, examining why something has failed and trying to attribute blame. As a result, governments often end up actually adding to the losses of failed enterprises. Governments instead need to find ways to efficiently and effectively release and recycle the resources that are stranded in failures. Accountability is important, but it becomes counterproductive if it ends up dissipating the value left in the investments.

References:

Castle, D and P. Phillips. Forthcoming in 2011. Science and technology in Canada: Innovation gaps and productivity traps. In B. Doern et al., How Ottawa Spends 2011-12, McGill Queen's University Press.

Conference Board of Canada. 2008. How Canada Performs: A Report Card on Canada. Ottawa: Conference Board of Canada: http://sso.conferenceboard.ca/HCP.aspx.

Council of Canadian Academies. 2009. Expert Panel on Business Innovation, Innovation and Business Strategy: Why Canada Falls Short. Ottawa; Council of Canadian Academies.

Council of Canadian Academies. 2006. The State of Science and Technology in Canada. Ottawa: Council of Canadian Academies: http://www.scienceadvice.ca/documents/Complete%20Report.pdf.

Gibbons, M., C., Limoges, H. Nowotny, S. Schwartzman, P. Scott and M. Trow. 1994. The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies. London: Sage.

Government of Canada. 2007. Mobilizing Science and Technology to Canada's Advantage. Ottawa: Public Works and Government Services Canada.

Industry Canada. 2006. Expert Panel on Commercialization: People and Excellence: The Heart of Successful Commercialization. Industry Canada:http://dsp-psd.pwgsc.gc.ca/Collection/Iu4-78-2006E-I.pdf.

Industry Canada. 2008. Competition Policy Review Panel: Compete to Win. Industry Canada: http://www.ic.gc.ca/eic/site/cprp-gepmc.nsf/vwapj/Compete_to_Win.pdf/$FILE/Compete_to_Win.pdf.

Kline, S. and N. Rosenberg. 1986. 'An overview of innovation', in R. Landau, and N. Rosenberg, (eds), The Positive Sum Strategy: Harnessing Technology for Economic Growth. Washington: National Academy Press.

Organization for Economic Cooperation and Development (OECD). 2010. Main Science and Technology Indicators 2010-11. OECD: Paris. Available at http://www.oecd.org/dataoecd/9/44/41850733.pdf.

Phillips, P. 2007. Governing transformative technological innovation: Who's in charge? Oxford: Edward Elgar.

Phillips, P.W.B., and D. Castle. 2010. Science and technology spending and innovation. In How Ottawa Spends 2010-2011: Recession and Realignment in the Harper-Ignatieff Minority Parliament, edited by C. Stoney and B. Doern. Montreal: McGill-Queen's University Press.

Science, Technology, and Innovation Council. 2009. State of the Nation 2008: Canada's Science, Technology, and Innovation System.Science, Technology and Innovation Council, available at http://www.stic-csti.ca/eic/site/stic-csti.nsf/eng/h_00011.html.

Statistics Canada. 2010a. Federal Scientific Activities 2010-2011. Ottawa: Statistics Canada.

Statistics Canada. 2010b. Gross Domestic Expenditures on Research and Development in Canada(GERD) and the Provinces. Ottawa: Statistics Canada.

Venables, A. 2006. Shifts in economic geography and their causes. The Economic Review 2006(4), 61-85. Available at: http://www.kansascityfed.org/Publicat/ECONREV/PDF/4q06vena.pdf.

Value Addition Through Genomics and GE^{3}LS **(**VALGEN) is a group of Canadian researchers with international partners investigating how Canada can benefit from applications of agricultural genomics, a new science which studies the effects of the entire set of genes making up a particular organism such as our familiar crops of wheat, flax, canola and corn. The project focuses on three crucial factors that affect how scientific discoveries make their way from laboratory to the marketplace. These are democratic engagement (the attitudes of the Canadian public with respect to new agricultural products and opportunities for them to participate in decision-making) governance and regulation (methods of better governing the production and use of new agricultural products) and intellectual property (in particular, collaborative mechanisms through which universities and industry can develop new agricultural products that meet the needs of Canadians). VALGEN is funded by Genome Canada with contributions from its partners which include the Government

of Saskatchewan, Western Economic Diversification, Genome Prairie, Genome Alberta, Genome BC, Genome Quebec, the Canola Council of Canada, and SRC Holdings Ltd. None of the core VALGEN researchers is paid out of VALGEN funds.