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Looking at Innovation from a Uniquely Canadian Perspective

The Case for a New Alliance of Practice, Policy and Scholarship

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Note from the Series Editor

We are happy to publish the first in a series of occasional publications by the Institute for Science, Society and Policy (ISSP). These publications are peer reviewed and freely available online. We would like to thank Dr Richard Hawkins, an ISSP Fellow, for producing a compelling and provocative contribution to the innovation debate in Canada. We believe it is this type of thinking that will truly move the issue forward.

Marc Saner
Director, ISSP

About the Author

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Executive Summary

This discussion paper argues that it is not productive to think about Canada's national innovation performance as a kind of statistical horserace with other countries. Instead, it proposes that it is time to reconvene the kind of alliance between industry, government and the academy that originally promoted the idea of enhancing public welfare by investing in innovation. It recommends that Canadians reconsider the terms of reference for this debate in the specific context of our own industrial history and composition.

Through a critical examination of past and present practice, and of emerging new ideas about the function and dynamics of innovation in a globalized economy, the paper explores several important questions about innovation in Canada and about the evolving role of public policy in Canada's innovation system. The following key points are stressed:

- Canadian policies for innovation have not kept pace with emerging new knowledge about the innovation process and how it actually creates wealth and prosperity. There is a serious and widening gap between what academic scientists internationally are learning about innovation and what policy-makers are doing about it.
- Innovation policy is not the same thing as technology policy. Technology is important, but very few of Canada's innovators are actually technology producers. Canadian innovation policies are unlikely to be effective if they continue to focus mainly or only on the technology producing sectors.
- The innovation performance of Canadian industry is often misunderstood because many of the comparative indicators are not oriented to the characteristics of our most economically significant industries, most of which are situated in the natural resources and services sectors.
- The view that Canada is evolving from a staples and medium value economy to a knowledge economy is misstated. Our unique advantage is that we are both a resource-based economy *and* a knowledge-based economy. Our resource industries are also among our most economically significant knowledge industries.
- It is especially important for Canada to start thinking about innovation differently because it is the *differences* in our industrial composition and orientation compared to other jurisdictions, *not the similarities,* that are likely to be our greatest source of future advantage and global leadership.
- Canada's Federal and Provincial strategies for innovation largely do not speak in the language of our strongest and most significant industries. Challenging this situation may well be the key to establishing once and for all what Canada's strengths and weaknesses really are as an innovative society.

The paper proposes three measures to reconnect the policy process with progress in understanding how innovation creates wealth:

1. *An innovation manifesto for Canada* – an independent, scientifically-grounded consensus statement from the academic community as to the current state of knowledge about innovation and the degree to which this is or is not reflected in current policies.
2. *A national audit of innovation knowledge* is needed that would assemble and reassess the existing body of knowledge relevant to innovation policy in Canada since the 1960s, and map out the extent, nature and regional distribution of our current competencies in innovation-related research.
3. *Prospective research on innovation in Canada's key industries* in order to develop descriptive and analytical models of how these industries are integrated into the national system of innovation, especially the resource-based industries whose characteristics do not fit the conventional profile of innovative industries.

The paper concludes that failure to address the growing gap between knowledge and practice in innovation policy will increase the risk that public resources for innovation and industrial diversification will be directed inefficiently to markets in which we have little or no comparative, positional or competitive advantage. It also concludes that by acknowledging basic realities about Canadian industry, vast horizons will be opened up for strategic thinking in creating dynamic innovation policies that will provide Canadian industries, including technology industries, with genuine and sustainable advantages in an increasingly competitive world.

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Looking at Innovation from a Uniquely Canadian Perspective: The Case for a New Alliance of Practice, Policy and Scholarship

I. Linking Innovation with Prosperity

In today's innovation obsessed culture, it seems somehow impossible that drawing a link between science, technology and prosperity was ever a new idea. But new it once was, and quite recently too. Immediately following WWII, Vannevar Bush published *Science the Endless Frontier* (1945), in which he proposed that public investments in science and technology would create a perpetual stream of economic growth. This idea was completely radical and also unprecedented, at least in the civil arena. The idea was not wholly original to Bush – elements of it dated back at least to the mid-19th century – but before the late 1940s and the urgent need to reconstruct most of the world's major industrial economies, few policy-makers had thought about it seriously.

That the idea originally acquired traction was the product of a unique confluence of industrial opportunity, policy necessity and academic engagement (Freeman & Soete 2007, 1997). The engagement of academics, especially in the social sciences, was of particular importance in this mix (Freeman 1994). If governments were to entertain the notion of investing public funds in innovation, someone had to figure out how to characterize this investment, how to define its terms of reference, and, crucially, how to monitor and measure its economic and social outcomes. This took considerable intellectual horsepower. It required academics to step boldly over entrenched disciplinary boundaries in order to formulate entirely new theories of industrial and social behavior, and to develop the analytical apparatus to investigate them. The result still resonates in the ways governments perceive innovation, how they invest in it, and in their expectations.

Today, however, the policy problem has moved on, especially regarding expectations. Investing in science and technology is no longer something that governments must justify – indeed, most would probably have to justify *not* investing. Likewise, despite government concerns about falling R&D investment in companies, industry as a whole does not seem to have difficulty producing new technology – indeed, we are awash in it. And even though in many ways global public investment in basic science has declined since the 1970s, academic scientists are exploring knowledge frontiers today that were unimaginable even 10 years ago.[1]

The issue these days is more about how *efficiently* government investments in innovation are exploited in the marketplace, and about how to get them to confer lasting competitive advantages upon specific national and regional jurisdictions. Inevitably, this has led to

[1] As de Sola Price (1961) first noted, increases in academic science budgets in the US, which had escalated massively since 1945, were, by the mid-1950s, failing to keep pace with the production of PhDs or with the cost increases of doing science. Thirty years later, Goldstein (1993) observed that this effect had only intensified, as it continues to do in most OECD countries.

comparisons and it has fuelled notions that some jurisdictions are more efficient investors than others. Inevitably also, comparisons create unease. Perversely, most of the world's most prosperous economies, including Canada, conduct these contests in a kind of purgatory; an ambiguous space where it is never entirely clear whether, on balance, the statistics indicate that advantage is being gained or lost. Feedbacks in this space tend naturally to be negative – either you are not doing enough to get to the top, or not doing enough to stay there.

In Canada, a steady stream of recent reports that draw heavily on such statistical comparisons has entrenched the view that Canadians are *especially* inadequate at converting knowledge into productivity and innovation-led growth (see e.g. Industry Canada 2011, 2007; Government of Canada, 2010; STIC 2009, 2011, and CCA 2009). This is perfectly true in some areas of industry, and certainly we cannot afford to be unconcerned or complacent about it. But it is demonstrably *untrue* in others. Indeed, if we track Canada through successive iterations of the OECD's science, technology and industry figures, our average performance in converting knowledge into markets does not diverge dramatically from most of the other countries that share the "middle earth" of innovation statistics. Canada never manages to compare favorably with the US, but then neither does the US ever compare all that well with Sweden, Norway, Israel or Finland. Moreover, Canada's figures tend fairly consistently to rank higher than those of countries like the UK, Australia and the Netherlands, hardly insignificant global competitors.

In this paper, I will argue that it is not productive to think about national innovation performance as a kind of statistical horserace, especially not for policy purposes and especially not in Canada. Instead, I will propose that it is time to reconvene the kind of alliance between industry, government and the academy that originally promoted the idea of enhancing public welfare by investing in innovation. Moreover, I will propose that we reconsider the terms of reference for this debate in the specific context of our own industrial history and composition.

My reasons are simple. In the 1960s and 70s, when the original terms of reference were defined for innovation as a policy issue, very little had actually been shown empirically about innovation as a social and economic phenomenon. Virtually every new investigation was an expedition into the unknown. This has changed spectacularly. The available conceptual and technical apparatus for characterizing and auditing national and regional innovation performance is now much broader and more sophisticated, and it has generated copious independent empirical work.

What is truly shocking is how little of the accumulating knowledge about innovation appears to be inflecting the policy debate in Canada at the actual policy-making level. Policy attitudes and actions remain oddly wedded to a much earlier incarnation of the innovation conversation. Mostly, policy makers pose the same old questions, and, mostly, they get the same old answers. In the following pages, I will explore some of the reasons for this disconnect, along with some of the possible solutions, by considering *seven key questions* about what innovation is, why it is important and how Canada can exploit it to the fullest extent.

II. Seven Key Questions About Innovation in Canada

Question 1: What is innovation and why should it concern policy-makers?

In common use, the term "innovation" is used interchangeably with "invention" and applied indiscriminately to any kind of change. It is often used synonymously with technology. In common use, finer distinctions are of little consequence. On the other hand, economists generally maintain that only the commercial application of an invention constitutes an innovation. But this is overly restrictive. Many economically significant innovations, e.g. innovations in organization, governance and professional practice have no essentially commercial characteristics and most are never traded as goods and services in their own right. Moreover, innovations do not have to be based on inventions at all, and they occur commonly in every sphere of human activity.

Early in the 20th century, the Austrian economist Josef Schumpeter (1912, 1939, 1942) proposed that the function of innovation is basically to create *new value* from *new combinations* of both new and existing factors. He proposed further that innovation involves decisive *qualitative* changes in how this value is produced such that existing sources of value are displaced through a process of "creative destruction". He saw this process as being motivated by entrepreneurs who break with convention, forge new combinations and impose them on the public. Schumpeter's core economic theory of innovation is that growth occurs *because* of change – that it is not simply producing more output that creates growth, but rather the ability to produce outputs in new ways, to create new outputs, and, crucially, to create new markets for them. Much has moved on since Schumpeter, but this basic concept has proven to be remarkably resilient and reliable in terms of explaining how industrial dynamics are related to growth across the entire spectrum of private and public enterprise.

Inevitably, the link between innovation and growth leads governments to link the international competitiveness of national industries with their ability and propensity to innovate, and especially to exploit new knowledge from basic and applied research. *Innovation policy* consists of interventions by government that are meant to stimulate innovation, and to capture the new value it produces in the form of competitiveness, employment, productivity and growth. Some interventions are structural and largely exclusive to government, e.g. higher education, training and basic research. Others are closer to the line between what might be considered public and private sector responsibilities, e.g. finance. All are meant to coordinate public and private resources in order to reap the benefits of innovation. If the theory is correct, and there is a lot of evidence that it is, governments should expect to see these policies create sustainable competitive advantages for industries within their jurisdictions.

Question 2: How has innovation been conceptualized in policy?

For many years it has been common to refer to national *systems of innovation* that are presumed to coordinate inputs from industry, government and the universities in various formal and informal ways (Freeman 2004; Nelson 1993). Nevertheless, coherent national innovation policies are a relatively recent phenomenon in most OECD countries. They

matured largely in the 1980s and 1990s in an unprecedented environment of rapid and sweeping technological advance. Understandably, they became associated almost exclusively with technology, and largely imprinted on the specific model of *information and communication* technology (ICT) with its low entry barriers, rapid formation and growth of new firms, extraordinarily high investment-to-earnings ratios, high attraction of venture capital, close connections with the academy and high positive returns to adoption. Indeed, the procedural formula that appeared to apply to the formation and growth of new ICT firms became a kind of blueprint for expectations of "knowledge-based" industries as a whole.

Unsurprisingly, the core objective of most innovation policy became simply to produce and apply more technology. To this day, virtually all of the strategies, programs and measures undertaken by Federal and Provincial governments in Canada and in most other OECD countries remain oriented to promoting industrial R&D and/or supporting the growth of start-up companies, mainly in the technology goods sectors (OECD 2010). Problematically, however, expectations that the ICT industries would yield continuous and sustainable growth and employment were optimistic. There have been several booms and busts in these industries in the past 15 years and the "formula" turned out not to be as easily linked to productivity or as readily transposable to other technology sectors as once supposed (Arundel 2007; Boyer 2004; Baily 2002; Pilat et al 2002; OECD 2001; Gordon 2000; Mandell 2000).

Accordingly, stimulated to a large extent by increasingly sophisticated analysis of how innovations actually occur within firms and industries, the techno-centric view of innovation is being challenged. Most prominent innovation scholars since Schumpeter have generally accepted that innovation is about much more than technical change, even when technology is a prime factor (e.g. see Freeman & Soete 1997; Baumol 1990; Dosi 1982; Nelson & Winter 1982; Rosenberg 1982; Ruttan 1959). However, current scholarship is making decisive strides in trying to understand innovation *analytically* in its key social, organizational, behavioral, cultural and even political dimensions. Thus, the field now encompasses a much broader intellectual scope that challenges many of the conventions and assumptions that have attached themselves to innovation policy over sixty years. These new perspectives are changing fundamentally how innovation is understood.

Innovation policies, however, have not caught up with the current state of knowledge and continue to focus primarily on technology production and adoption. Most of the evolution in innovation policy in the OECD countries (where there has been evolution at all) relates to the reorientation of existing approaches and measures to *new* technological champions, like nano or bio technology, or renewable energy, rather than to any significant reassessment of the nature and function of innovation in today's economy. This belies a serious disengagement between the practice of policy-making, which now mainly scrambles just to keep up with new scientific and technological developments, and the outcomes of scholarship, which might help put all of this into more productively manageable contexts. The fault lies on both sides.

Question 3: What is the problem with this conceptualization?

Two recent reports – the report of the Council of Canadian Academies Expert Panel on Business Innovation (CCA 2009) and the report of the Independent Panel on Federal Support to Research and Development (the "Jenkins" Panel) (Industry Canada 2011) are in many ways emblematic of the problems inherent to the current Canadian conversation about innovation. On the one hand, both reports are of high analytical quality and contribute long-overdue critical assessments of the effectiveness of current Federal policy instruments and programs. On the other hand, their conclusions are based largely on empirical evidence as drawn from conventional *input* indicators like R&D investments, patenting and technology adoption, and often upon highly stylized interpretations of how these indicators are linked to economic outcomes like employment and growth. The problem is not that this analysis is somehow wrong. It is *not* wrong, and it yields a wealth of knowledge. The problem is that technology-focused input indicators tell only a small part of the innovation story. This can lead easily to misconceptions as to what the story is really about.

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Input indicators are basically proxies; changes in a measurement of one phenomenon are assumed to reflect change in an associated phenomenon. In most cases, proxies were adopted in the first place simply because they were the only available and reliable longitudinal data that could be associated with innovation in any reasonably robust way. Nevertheless, proxy measurements have often been criticized, to some extent justly, as being more the product of *available* proxy data than the product of a robust theory. In other words, because data can be obtained on R&D expenditures, patenting and so forth, the tendency is unavoidable for definitions of innovation to be biased towards these inputs (Stoneman 2010; Godin 2005; Archibugi & Pianta 1996; Basberg 1987). When these biases are eliminated conceptually, however, the entire innovation landscape looks very different.

The conventional depiction of this landscape is coming under increasing criticism as being too monochromatic to fully characterize innovation and its impacts across a broad enough spectrum of institutions and practices. In particular, this criticism is aimed at the historical tendency to define innovation mainly or only in terms of technical change – as a problem of capital formation or deepening – and not in terms of its social, cultural political and commercially strategic dimensions (OECD 2011). This has led to the equation of *innovation policy* with *technology policy*, or even *higher education policy*, when in practice these are quite different species (Gault 2010). The Jenkins Report in particular makes specific reference to these difficulties and argues for a much expanded view of what innovation is and how its inputs and outputs are assessed.

The key difficulty remains that the core economic and organizational models that are commonly applied to innovation, along with most of the statistical indicators that are used to assess the innovation performance of national enterprises, were based originally, and almost exclusively, upon observations of historical practice in conventional manufacturing

sectors and/or in technology producer goods sectors (see Alic 2001). In response to this problem, the "methodological" definition of innovation (the one used by agencies like the OECD, Statistics Canada or Eurostat to define what is actually measured) has undergone substantial evolution over the past 20 years (Gault 2010; OECD/Eurostat 2005). In common practice, however, innovation has become conflated and confused with a cluster of activities surrounding R&D, which is only one of many possible *inputs* to innovation, but certainly *not an output*.

Problematically also, the definition of R&D itself has tended to be somewhat flexible from country to country, particularly as concerns what counts as basic or applied science in this context. It is instructive in terms of the arguments that follow to look at the definition of R&D as contained in the Frascati Manual (OECD 2002) which sets out the standards for collecting national data on R&D. Here R&D is defined simply as *"…creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man* (sic)*, culture and society, and the use of this stock of knowledge to devise new applications.".* In other words, R&D is the production and application of virtually *any* kind of knowledge to *any* end.

The practice in most innovation policy regimes, however, is to skew this definition towards *technical* knowledge (Stoneman 2010; Hawkins et al 2007; Salter et al 2002). Accordingly, not only have policies reflected a very narrow segment of the innovation spectrum, they have been equally myopic about what constitutes R&D. This has been confirmed over time by various innovation surveys in several regions of the world. Most have shown consistently that many firms report making innovations, but *do not* report performing R&D, at least R&D defined in terms of engaging directly in the development of technology (Gault 2010; Arundel et al 2008; Salazar & Holbrook 2004). By the OECD definition, many of these firms may well do R&D or some close equivalent that simply is not counted or even detected as such. In Canada, for example, R&D tends to be defined statistically in terms of activities that qualify for R&D tax credits, all of which specifically exclude everything that does not relate exclusively to inventing new technology. How economically significant are the excluded activities? We do not know. As until quite recently they were assumed to be of *no* value, nobody bothered to measure them.

This is even more problematical in that by such narrow definitions, only a very few firms in just a few sectors actually perform most of the R&D globally. As indicated in the more recent Innovation Surveys conducted by Statistics Canada, about 50% of Canadian R&D is performed by typically fewer than 100 companies, the other 50% distributed among fewer than 20,000 companies (Gault 2010). Even allowing for the fact that about half of our roughly two million business establishments are comprised of single proprietors, R&D is a highly concentrated activity in Canada. But is this actually a problem? Similar distributions apply in most OECD countries. Various innovation scorecards have shown consistently that the vast majority of R&D intensity (firms that invest more of their own revenue in R&D than the OECD average) is concentrated in fewer than 1000 firms worldwide and overwhelmingly in fewer than a dozen sectors (e.g. see DTI 2006; BIS 2010).

This indicates that R&D as conventionally understood in the technology producer sectors is a marginal activity in most other sectors. Crucially, however, this does *not* mean that

enterprises in these other sectors do not innovate. It also does not mean that they are technologically unsophisticated. But it *does* mean that how and why they innovate is not likely to become evident if they are explored analytically as if they *conform or ought to conform* to the R&D-intensive model that is normally applied to a few high-performing "tech" sectors. This is especially a problem for Canada because the majority of our most economically significant sectors – basically our natural resource and financial services sectors – are for the most part capital-intensive technology adopters, rather than R&D-intensive technology producers.

Question 4: Is Canada good or bad at innovation?

The answer is that we do not know, for the simple reason that the Canadian innovation system has never been comprehensively assessed quantitatively *on its own terms* – according to its own historical antecedents, its unique social and industrial characteristics, and, most crucially, free from prior assumptions about how it *ought to* behave as drawn from comparisons with other jurisdictions, and with reference only to a few selected industries that are considered, often quite arbitrarily, to be more innovative or higher-tech than others.

The Canadian innovation system has never been comprehensively assessed quantitatively on its own terms…

This problem is by no means unique to Canada. Moreover, it is highly instructive that in the relatively few instances where scholars have carried out independent, historically-contextualized empirical investigations of national innovation systems, refreshingly different pictures have emerged of how these systems develop and how they work. The insightful studies of evolution in the Norwegian innovation system by Fagerberg et al (2009), or of the UK by Cosh et al (2006) are especially noteworthy in showing how the industrial and commercial histories of different countries still generate unique effects upon their innovation capabilities and propensities.

It is perhaps ironic in this context that Canadian scholars have been very concerned with such matters for many years. Since the 1920s when Harold Innis began writing his now classic economic histories showing how the social and economic foundations of Canada were inextricably linked to innovative combinations of technology and geography (Innis 1923, 1930, 1940), themes of this nature have permeated much of Canadian innovation scholarship (e.g. see De la Mothe and Pacquet 1988, De Bresson 1996; De Bresson and Lampel 1991). Moreover, the Innovation Systems Research Network, doubtless the largest single Canadian research effort in this field to date, provided ample evidence that both the strengths and weaknesses of our innovation system are rooted more in the regional and interregional networking dynamics of key industries than they are in any specific type of capital or R&D investment.[2]

[2] The ISRN has produced copious studies demonstrating various dimensions of these networking dynamics. Collected insights can be found in Holbrook & Wolfe (2000) and in Wolfe & Lucas (2004).

Canada might be one of the most innovative countries in the world or one of the least. We can never really know if we do not follow these leads and develop ways to measure a wide enough range of factors that are appropriate to our industrial history and composition, and that do not presuppose any idealized model, structure or outcome.

Question 5: Do existing innovation policies work?

Particularly over the past 25 years, most OECD governments have funded various programs targeted specifically at promoting innovation. Although there are many jurisdictional variations and differences in emphasis, most of them fall into five broad categories: (1) research personnel, services and infrastructure, (2) firm-level R&D subsidy, (3) coordination and networking, (4) support for the commercialization of intellectual property, and (5) business development support (mostly for SMEs). In one way or another, all of these programs are oriented to promoting the production and adoption of new technology. The most commonly expected indicators of success from these policies are usually framed in terms of overall increases in aggregate national R&D expenditures relative to other countries. Basically, if these policies are in place and working, so the logic goes, we should expect to see a reasonably significant increase in R&D investment, especially in firms, with a corresponding increase in growth and employment. So why in *most* cases do we *not* see this? That's right, in *most* cases – for by no means is Canada alone.

For many years, the OECD has been producing league tables of national R&D investment, ranked according to the source of these inputs, principally business, government, and higher education (OECD 2010). The bellwether indicator is the gross domestic expenditure on R&D (i.e. from all public and private sources) expressed as a percentage of GDP – the so-called GERD. To its credit, the OECD has always encouraged this regime to evolve as new knowledge about innovation has emerged, and has always cautioned against using these tables as blunt instruments for policy-making (Gault 2010; OECD 2011). Recently, the organization has launched a major initiative to revamp its innovation policy approach and apparatus in order better to reflect the current state of knowledge and to remedy some of the chronic misunderstandings and misconceptions about what innovation indicators really are and what they actually mean (OECD 2011). Disappointingly, such efforts often go un-noticed in the member countries. Certainly Canada's policy-makers appear to be moving steadily towards a *more* rather than less exclusive association between innovation and technology, even if they may have taken on board that the ways in which they support R&D may be in need of an overhaul.

Certainly there is an important relationship between technological capabilities and national industrial performance. Technology goods and services yield enormous positive externalities. The problem is that the benefit of a technology investment is not a function of its magnitude. Rather, it is a function of the whole environment in which it is undertaken and its outcomes applied (Salter et al 2002; Levinthal 1997; Cohen & Levinthal 1990). This environment is partly the product of technical learning, but even *more* the product of organizational, managerial, social and cultural learning; the application of "*knowledge of man* (sic)*, culture and society*" as Frascati insists. Much of this *social knowledge* is as much a product of systematic research as technical

knowledge. Thus, it does not follow that because a jurisdiction spends proportionally more or less on technology development, that proportionally more or less benefit will accrue. Accordingly, by focusing too exclusively on R&D-oriented indicators, perverse and somewhat paradoxical observations typically emerge.

It has often been noted, for example, that over many years there have been few significant changes in the positions of member countries in OECD league tables. In the aggregated GERD table, most countries have stayed in much the same positions over extended periods of time – the Nordics and Japan always at the top, the rest of the G8 (excluding Russia) and EU15 countries within a relatively narrow range in the middle, with the remainder falling off towards the bottom (OECD 2011, 2010). The only notable exceptions have been Korea and Israel, whose rise from near the bottom of the table to the very top has indeed been rapid and dramatic. More troubling, it is very difficult to track any consistent relationship between positions in the tables, which do not change a great deal, and actual national economic performance, which can vary considerably. The most obvious example is of course Japan, which always ranks as one of the leading R&D performers, but whose economy has been stagnant for nearly two decades.

For policy-makers in most OECD countries, the reality is that these tables seldom look very encouraging. Indeed, to the extent that GERD is assumed to be the bellwether indicator, they appear to indicate that most national innovation policies have failed quite consistently and rather badly. The relative stability of the league tables would appear, at best, to support only a very weak case that the current range of technology-oriented innovation policies have yielded significant competitive advantages to any specific jurisdiction, which, after all, is what governments seek most as an outcome from economic policy.

Reality is of course much more complicated. The discrepancies might be explained to some extent by time lags between when R&D investments were made and when returns appeared, except that the R&D tables have proven to be remarkably less elastic over long periods than the growth tables have been. It is also possible that the returns on R&D investments have been realized collectively rather than individually. The aggregated effect of policy measures may well be that they have contributed to maintaining global R&D levels from which all have benefitted. Disappointingly, however, there is little clear empirical evidence that they have *increased* them. The OECD average has remained stubbornly pegged at roughly 1.5-2% of GDP virtually since these measurements were inaugurated.

Another part of the reason may be that most national, sub-national and *supra*-national jurisdictions have been implementing a remarkably similar range of policies and measures for going on 25 years. Although at various times some jurisdictions appear to obtain more value from these measures than others, essentially they all do most of the same types of things most of the time. This suggests the rather obvious explanation that they are susceptible to a Red Queen effect. As with Alice in Wonderland, everybody is running as fast as they can in order to stand still. The same policies designed to achieve the same objectives are simply cancelling each other out in terms of yielding any overall advantage to any one jurisdiction.

The problem with this explanation is that although most of the measures are similar, there are many significant differences in the amount of expenditure on each type of program in each jurisdiction, and in the proportion of direct support through financial subsidies and procurement contracts, to indirect support through fiscal measures. It is noteworthy that Canada provides most of the support for R&D in firms through the tax system (by far the highest proportion in the OECD). In contrast, the US provides very little support through this route, most US government-funded R&D being embedded in the public procurement system. Other countries range between these extremes. Regardless of how support is provided, however, it appears to have little impact on the league tables.

The more plausible explanation is that regardless of how effective any of the policies might be, innovation is more weakly and/or exclusively associated with R&D as conventionally defined than previously supposed. Or, just as likely, that the nature of this relationship is *different* than previously supposed. Scholars are making increasingly strong theoretical and empirical cases that the relationship between innovation and growth is non-linear; that the outcome will be generated by *how new combinations of factors interact* and not by increases or decreases in any particular factor (Metcalfe & Foster 2007; Katz 2006, Kauffman et al 2000; Durlauf 1997). Others point to the significance of innovation factors that typically are left out of R&D-oriented indicators; e.g. innovation in pricing and finance, in business models, in marketing, in design aesthetics, and, most crucially, in entrepreneurial behaviors and the transformation of relationships between producers, consumers and products (see e.g. Dew et al 2011; Stoneman 2010; Swann 2009, 2001; Potts et al 2008; Hawkins & Vickery 2008; von Hippel 2005, 1988; Cowan et al 2004, McMeekin et al 2002; Douglas & Isherwood 1996).

All of this suggests that many of the goals to which innovation policies have been oriented are somewhat artificial. They have been chosen by discriminating between sectors such that R&D-intensive technology enterprises are assumed to be more innovative than others by definition. Many aspects of the new OECD approach to measuring innovation focus specifically upon how to expand the measurement agenda beyond technology-oriented input indicators. However, it remains to be seen how seriously OECD governments will respond to this new agenda. Historically, their collective record of basing innovation policies on indicators of any kind has not been good (Gault 2010; Arundel 2007). Moreover, national statistical agencies are limited by their mandates as to which data they can collect, and in the degree to which they can adopt new statistical definitions and surveys. They are also often limited in their ability to experiment because of inertia in the policy regimes they serve. The result can be a self-reinforcing stalemate that frustrates both the agencies and their clients.

To sum up, it is *not* that R&D in technology industries is unimportant in the innovation landscape. It most certainly is *vitally* important. But it is not the whole landscape. Understanding the relationship between innovation and growth *strategically* requires intelligence about far more than the R&D spend of enterprises whose business models are contingent upon this output – basically, capital goods producers. It also involves conceptualizing innovation in terms far broader than technical change alone. This yields the kind of strategically essential knowledge that a Steve Jobs succeeded in bringing to

Apple, but that maybe no one has yet been successful enough in bringing to potential Canadian competitors in such markets.

Question 6: Why is it important for Canada to think about innovation policy in a different way?

One of the most important elements of any theory of innovation-led growth is that history matters (Arthur 1989; David 1985). Where you start – your initial comparative advantages in human, economic and physical resources – plays a huge role in determining where you can go. In some circumstances, these path dependencies can be a source of enormous disadvantage; inhibiting creativity, sucking up available human and investment capital and driving economies to dead ends. But if exploited intelligently, they are also one of the primary ways in which unique and sustainable advantages can be created (see David & Wright 1997; Wright 1990, 2004).

It is especially important for Canada to start thinking about innovation in these terms because our industrial composition and orientation differs substantially from economies like the US, Japan, Germany or Korea, and because it is the *differences, not the similarities,* that are likely to be our greatest source of future advantage.

Policy strategies continually characterize Canada as being in transition from a staples and medium-value manufacturing economy to a "knowledge economy", based explicitly or by implication in science and technology, and often expressed simplistically in terms of a "digital" economy. The reality, however, now as 100 years ago, is that the Canadian economy has its deepest roots in natural resources, if not always directly. Like it or not, in terms of its transformative effects on both the Canadian economy and the position of Canada in the world, learning how to extract oil from sand is the single most significant innovation in Canadian history since Marquis wheat! It also supports the largest single science and engineering complex in Canada, and one of the largest in the world.

Like it or not … learning how to extract oil from sand is the single most significant innovation in Canadian history since Marquis wheat!

Although by the strictest definitions, conventional resource extraction (including energy resources) and the production of agricultural commodities contribute only about 7% of GPD directly, they generate enormous positive externalities. Our manufacturing, financial, construction, logistics, utilities, environmental, educational, technical services, business services, wholesaling and retailing sectors all have very significant stakes in enterprises oriented in some respect to the discovery, extraction, processing and transportation of raw materials, energy commodities and agricultural commodities. The Canadian resource industries are global in reach and constitute an enormous market for a huge basket of intermediate goods and services from both Canadian and global sources. Consistently about half of the 10 largest and most profitable Canadian companies are situated in the resource industries. This proportion increases as we look at the top 50, the top 100 and so on. Our principal securities exchanges deal mainly with resource investments. Our currency is pegged to resource prices.

If we consider where the value is produced in Canada, notable differences can be seen in the composition of this value as compared, for example, to the US. Of the 100 largest Canadian firms in the most recent Globe & Mail listing, only a handful are situated in the "technology" sectors (apart from communications carriers maybe 10%). Most of our 100 most profitable firms are situated in the financial, logistics, wholesaling, retailing, resource and agricultural sectors (Globe & Mail 2011). In contrast, consistently about 35% of the top 100 firms on the US Forbes list are in the information technology and bio-medical sectors. But what does this mean? Basically it indicates that the US has a more substantial range of domestic sources for some technologies – mainly bio-medical and IT. But the US is also a major technology importer. Indeed, most OECD countries typically import as much or more technology as they export.

Canada is in a similar position to most countries of similar size in that we have fewer domestic sources for many technologies than larger countries might have. However, this is *not* a good reason to assume that by achieving a different balance in industry composition, Canada will necessarily accelerate progress towards "knowledge economy" goals. To the contrary, we already have the dual advantage of being both a resource economy *and* a knowledge economy. Our challenge is to recognize, preserve and significantly enhance this vital advantage.

Consider for example that our resource sectors have extraordinarily *long supply chains*, meaning that they must procure an enormous variety of goods and services from many other sectors, simply in order to operate. Consider also that they have extremely *deep value chains*, meaning that they have the potential to produce and consume products and services that range from the most basic unrefined commodity to the most technologically sophisticated high value product or service that might be derived from that commodity.[3] This means that many of our resource industries encompass and underpin production of many of our highest value-added exports in technology and expert services. It also means that they have high potential to generate entirely new forms of value. In contrast, many of the tech sectors have remarkably short and highly specialized supply chains. Their products yield most of their value only when integrated into the supply and value chains of other industries. In Canada, this often means integration into resource and resource-based industries, or into financial and other services industries.

Thus, although often differing significantly in timing, location and extent, there are no *prima facie* reasons to assume that our resource-based industries are intrinsically any more or less innovative than any of our other industries (e.g. see Holbrook & Hughes 2001). Many have maintained historically strong vertically-integrated knowledge chains extending all the way from the leading edges of theoretical science to the market floor. Moreover, as prominent scholars have long argued, it is primarily in the capital-intensive technology *adopting* sectors where the productivity latent in technology goods is actually realized (Cosh & Hugues 2010; Tassey 2004).

[3] A very good illustration of the length of the supply chain and the depth of the value chain in one of Canada's key resource-based sectors is provided in a recent Conference Board of Canada report on the Canadian food industry (CBC 2011).

The primary concern for Canada is not the composition of our industrial base, but the degree to which we add high levels of value in all of our key positional industries. From the point of view of enhancing Canada's stature as an innovator, it really *does matter* exactly which kinds of products actually flow through the Keystone and other pipelines once they are built. Export the upgrading and you export most of the opportunities to innovate and with them most of the sustainable high-value employment and most of the spin-offs. Likewise, it really does matter whether agricultural, forest and mineral products leave our shores in low or high value-added forms. And it matters most that we anchor the foundational knowledge and skills that drive innovation in these industries securely to our shores.

Achieving such goals, whether in resources, financial services, transport or any other industry is innovation policy writ large. And yet, Canada's Federal and Provincial measures and strategies for innovation and the knowledge economy largely do not speak in the language of our strongest and most significant industries. Too often these are regarded merely as receptacles for "new technology", elusively described. They are not characterized aggressively as "knowledge" industries that can, should and do generate a broad spectrum of innovation. Neither are our innovation policies and strategies oriented significantly to them. Challenging this situation may well be the key to establishing once and for all what Canada's strengths and weaknesses really are as an innovative society.

Canada's Federal and Provincial measures and strategies for innovation and the knowledge economy largely do not speak in the language of our strongest and most significant industries.

Question 7: What needs to be done?

At this moment, for all of the above reasons, there remain significant gaps in knowledge concerning exactly where Canada stands in terms of generating prosperity through innovation, and what might need to change to ensure that we improve, or even to sustain the advantages we already possess. For at least three decades, Statistics Canada has been a world leader in formulating and applying surveys of innovation and new technology adoption. These surveys have produced many invaluable insights into the Canadian innovation system, including confirmation that Canadian firms innovate regardless of whether or not they engage in R&D as such. The agency has also endeavored to expand this focus by extending the survey capability to business services and to some of the resource industries. Assuming these initiatives are preserved, which in today's policy environment is not certain, excellent data on many aspects of innovation in Canada will continue to be available.

The issue is how to mobilize exciting new knowledge about innovation as a social and economic phenomenon in a way that will be informative for government in assessing policy options and performance, but also useful for a broad range of Canadian industries in developing innovation-centered competitive strategies. Both industry-wide and targeted national surveys will continue to play important roles in this mobilization. But innovation is required also in the development of new analytical constructs and empirical methods, especially as regards enterprises in resources and services whose contribution

to innovation-led growth in Canada is at present almost certainly underestimated, misrepresented or simply unknown.

Filling in these knowledge gaps will require reinvigoration of the industry-government-academy alliances that produced the first waves of knowledge about the role of innovation in a modern industrial economy. In particular, it will require the aggressive re-engagement of Canadian scholars in developing descriptive and analytical models of Canada's innovation system, both as a discrete entity and in terms of how it interacts in a global marketplace. To make a start, I propose that the following measures are essential:

An innovation manifesto for Canada

In recent years, most of the opportunities to engage in a national conversation about innovation in Canada have tended to originate with governments or with committees and commissions set up by governments. The original government-industry-academy alliance that first defined the terms of reference for innovation as an economic and social strategy was somewhat unique in that to a large extent it was enabled, even driven, by concepts originating in academic science, especially the social, economic, organizational and administrative sciences.

…take the initiative of crafting an independent, scientifically grounded and clearly articulated consensus from the academic community …

Missing from the current mix is a clear and concise statement or position from the growing community of Canadian scholars who are exploring the leading edges of this field today, and who have perhaps the best understanding of significant advances in knowledge about how innovation works in the contemporary globalized economy. One way to re-invigorate the national debate about innovation is for them to take the initiative of crafting an independent, scientifically grounded and clearly articulated consensus from the academic community (including elaboration of dissenting positions), as to the current state of knowledge and the degree to which this is or is not reflected in policy, or even in the kinds of questions posed by policy-makers. The document should be written for a general audience and distributed publicly in order to bring as many constituencies as possible into the conversation.

A national audit of innovation knowledge

What recently the US National Science Foundation has termed the "science of science policy" (Gault 2011) – systematic research into science, technology and innovation as social and economic phenomena – actually has very deep historical roots in Canada. Some of the seminal work that established "innovation studies" as an interdisciplinary field in the social sciences was produced in Canada between 1960 and 1980 by agencies such as the Science Council, the Economic Council, Statistics Canada, the IDRC and Communications Canada. Beginning in the 1970s, several of these agencies were abolished, and Canada lost many of the important institutional footholds that had been crucial for maintaining a leading position in this field.

However, many of the experts who made these seminal contributions are still active in various academic, government and industry capacities. A wealth of reports and studies is contained in public and personal archives scattered across the country. There is an urgent need to assemble and reassess the existing body of knowledge relevant to innovation and innovation policy in Canada since the 1960s, and to map out the extent, nature and regional distribution of our current competencies. In order to generate some continuity, it may be productive to orient this map to the various new challenges for innovation performance assessment as identified in the Jenkins Report.

Prospective research on innovation in Canada's key industries

We cannot possibly understand the dynamics of innovation in Canada without first understanding how all of our key industries are integrated into the national system of innovation, especially the resource-based industries whose characteristics have not been integrated appropriately into the national regime of innovation measurement because they do not fit the conventional profile of innovative industries. Prospective interdisciplinary research, involving both qualitative and quantitative components, is required urgently in order to gain an in-depth understanding of how, why and where these industries innovate, and, more crucially, how they might interact with other industries in Canada and how they might spawn entirely new enterprises. Such an exercise is essential for producing a robust regime of testable hypotheses about innovation in Canada that are grounded in Canada's unique industrial fabric.

III. Conclusion – What Happens if We Do Nothing?

If the above inconsistencies and gaps in knowledge about the Canadian innovation system continue to be ignored, there is a significant risk that too many of our policies and public resources for innovation and industrial diversification will be directed inefficiently to markets in which we have little or no comparative, positional or competitive advantage. This creates a high risk that too few resources will flow to promoting productive and sustainable development in markets with immediate growth potential and in which already we enjoy considerable and even potentially exclusive opportunities and advantages over the long term.

…there is a significant risk that too many of our policies and public resources for innovation and industrial diversification will be directed inefficiently to markets in which we have little or no comparative, positional or competitive advantage.

Admitting to ourselves that we are primarily dependent upon natural resources and financial services for our national prosperity – which consistently outperforms OECD and UN averages – is not an admission that we are not good at science and technology. Nor does it blunt any imperative to become better. To the contrary, it boosts this imperative. Likewise, admitting that on balance relatively fewer Canadian enterprises pursue business models associated with technology producer goods than we see in some of the other OECD jurisdictions is not an admission that we are deficient or incompetent in these areas. Nor does it negate the imperative to invest in them as needs and opportunities arise.

Simple recognition of such basic facts about Canadian industry opens up vast horizons for strategic thinking in creating dynamic innovation policies that will provide Canadian industries, including technology industries, with genuine and sustainable advantages in an increasingly competitive world.

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