

# **INVESTING IN CANADA'S FUTURE**

Strengthening the Foundations of Canadian Research



CANADA'S FUNDAMENTAL  
SCIENCE REVIEW

2017



## CANADA'S FUNDAMENTAL SCIENCE REVIEW

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*April 10, 2017*

The Honourable Kirsty Duncan  
Minister of Science  
Government of Canada

Dear Minister Duncan,

We are very pleased to submit the final report of the Advisory Panel on Federal Support for Fundamental Science. The report would not have been possible without the dedication and expertise of a very large number of individuals inside and outside the Government of Canada; they are acknowledged elsewhere. The report has also been informed by our consultations with stakeholders and the public, and by literature reviews and analyses of digital and printed materials from a wide variety of sources, including international research funding agencies. However, the findings and recommendations ultimately reflect our consensus interpretations of the available evidence, and our considered judgments as to what course of action the Government of Canada should follow to strengthen the foundations of Canadian research. We are grateful for the opportunity to provide this advice to you and your Cabinet colleagues. We also remain available, as needed, to assist with interpretation of the report and to advise on its implementation.

Sincerely,

**C. David Naylor**, *Professor of Medicine,*  
University of Toronto (Chair)

**Robert J Birgeneau**, *Silverman Professor*  
*of Physics and Public Policy, UC Berkeley*

**Martha Crago**, *Vice President – Research*  
*& Professor of Human Communication*  
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**Mike Lazaridis**, *Founder & Managing*  
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# ABSTRACT



Canadian accomplishments in science and scholarly inquiry have long been a source of national pride. However, by various measures, Canada's research competitiveness has eroded in recent years when compared with international peers. The change coincided with a period of flat-lining of federal spending through the four core funding agencies that support researchers in universities, colleges, institutes, and research hospitals. In those years funds were also directed preferentially to priority-driven and partnership-oriented research, reducing available support for independent, investigator-led research by frontline scientists and scholars.

The proportion of federally derived funding for research has also declined. Canada ranks well globally in higher education expenditures on research and development as a percentage of GDP, but is an outlier in that funding from federal government sources accounts for less than 25 per cent of that total, while institutions now underwrite 50 per cent of these costs with adverse effects on both research and education.

Despite high levels of talent, expertise, and dedication on the part of those serving each agency, there is evidence to suggest that the overall stewardship of the federal research ecosystem needs to be strengthened. Coordination and collaboration among the four agencies is suboptimal, with variations in governance, administrative practices, and funding priorities within and across agencies that are not explicable either by disciplinary differences or by the needs of the relevant research communities. Investments in infrastructure and related operating costs are not consistently aligned, and funding for areas such as international partnerships or multidisciplinary research is uneven. Early career researchers are struggling in some disciplines, and a career-spanning strategy for operating and personnel supports is lacking. For example, flagship personnel programs such as the Canada Research Chairs have had the same value since 2000. Levels of funding and numbers of awards for students and postdoctoral fellows have not kept pace, variously, with inflation, peer nations, or the size of the applicant pools.

This report accordingly outlines a comprehensive agenda to strengthen the foundations of Canadian extramural research. It recommends legislation to create an independent National Advisory Council on Research and Innovation (NACRI). Working closely with Canada's new Chief Science Advisor (CSA), the new council would raise the bar in terms of ongoing evaluations of all programming. The report also recommends wide-ranging improvements to oversight and governance of the four agencies, including the appointment of a coordinating board chaired by the CSA. Other changes would promote lifecycle oversight of national-scale research facilities, and improved methods for initiating, reviewing, and renewing or terminating contribution agreements with external non-profit entities operating in the research realm.

Concurrent with these improvements designed to augment the effectiveness, accountability, and efficiency of various elements of the system, significant reinvestment is required. This reinvestment should be undertaken on a multi-year basis, coupling predictability with better planning. Targeted increases are recommended based on benchmarking, contingent in several cases on presentation and approval of multi-agency plans for improvements to programs. New spending would be balanced across:

- investigator-led research operating grants (the highest priority);
- enhanced personnel supports for researchers and trainees at different career stages;
- targeted spending on infrastructure-related operating costs for small equipment and Big Science facilities; and
- enhancement of the environment for science and scholarship by improved coverage of the institutional costs of research.

The cumulative base increase would move annual spending in steady-state across the four agencies and closely related entities from approximately \$3.5 billion to \$4.8 billion. This phased-in increase requires dedicating an additional 0.4 per cent of the Government of Canada's annual budget to an area of shared jurisdiction where federal leadership is essential and welcomed. Given global competition, the current conditions in the ecosystem, the role of research in underpinning innovation and educating innovators, and the need for research to inform evidence-based policy-making, it is also among the highest-yield investments in Canada's future that any government could make.

# EXECUTIVE SUMMARY



## 1. Mandate and Consultations

The Advisory Panel on Federal Support for Fundamental Science was appointed in June 2016. Our mandate entailed a review of the federal system of supports for extramural research, understood to be research conducted by scientists and scholars employed outside of federal, provincial, or territorial government departments and agencies.

Our mandate was further clarified as follows. We were expected to cover the full range of disciplines involving peer-reviewed science or inquiry, with either a basic or applied orientation. As well, our focus was to be on programs supporting knowledge generation, as contrasted with programs oriented primarily to fostering partnerships with industry or civil society, or promoting knowledge translation, innovation, and commercialization.<sup>i</sup> We focused our work primarily on the four pillar agencies that support the Canadian extramural research ecosystem: the three granting councils—the Natural Sciences and Engineering Research Council (NSERC), the Canadian Institutes of Health Research (CIHR), and the Social Sciences and Humanities Research Council (SSHRC)—as well as the federal infrastructure agency, the Canada Foundation for Innovation (CFI).

Consistent with our mandate, we examined funding arrangements in peer nations. Our assessments have been shaped by their international practices, and by the organizing principles we observed in the strongest agencies and programs here and abroad. These principles may be encapsulated by the following brief descriptors: World-leading and Globally-collaborative; Meritocratic; Independent yet Accountable; Coordinated; Balanced; Responsive; Talent-focused; Diverse and Equitable; Efficient; and Outward-facing.

The Panel's call yielded 1,275 written submissions from individuals, associations, and organizations. We also convened roundtables in five Canadian cities, engaging some 230 researchers at different career stages in conversations on diverse topics. We identified many strengths and found much to commend.

Our mandate, however, was to identify gaps and address specific questions posed by the Minister of Science. The concluding chapter of the report addresses each of those questions. This précis in contrast tracks the logic of the report itself, opening with an overview of the system's funding and performance and then summarizing our recommendations in three interlocking categories.

## 2. Funding

Canadian gross domestic expenditure on R&D from all sources relative to GDP (GERD intensity) has been declining slowly over the last 15 years, as contrasted with our G7 peers and key east Asian nations. Worldwide, including non-OECD nations, we are no longer in the top 30 nations in terms of total research intensity. HERD is a subset of GERD related to extramural research conducted by institutions of higher education and affiliates. In 2014 Canada's HERD intensity was seventh in the OECD, but highest in the G7.

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i The Advisory Council on Economic Growth has recently recommended a wide-ranging review of federal supports for innovation. We have endorsed that recommendation (R1.1), and indicated areas of synergy with our other recommendations.

This higher standing compared with overall R&D spending is often linked to the growth in federal research spending that started in 2001, and seems at odds with the extensive concerns about funding that we heard from scientists and scholars. However, in 2015 almost 50 per cent of HERD in Canada was funded by universities and colleges themselves, while the federal government contributed only 23 per cent. Internationally this is a highly anomalous situation, and it is having adverse effects on both research and higher education across Canada.

As well, growth in federal spending was matched by growth in the number of people engaged as researchers at Canadian universities and colleges. Thus, in constant dollars, granting council funding per researcher has been in steady decline since 2008-09. We examined a number of international peer jurisdictions and found no evidence that there was either unusually fast growth in Canada or that there is now a uniquely Canadian glut of extramural researchers. Indeed, for doctoral-level graduation rates, Canada ranked 22<sup>nd</sup> among 35 comparator OECD countries in 2013; contrary to popular belief, Canadian enterprises in the for-profit and not-for-profit sectors are hiring PhDs at a rate commensurate with rising graduation rates.

The years from 2006-07 to 2013-14 also saw a shift in funding away from independent research, be it basic or applied, that allows individuals or teams to define their topics and/or the structure of the research collaboration. We estimated that scholars, scientists, and trainees wishing to pursue fully independent research work saw a decline of available real resources per researcher of about 35 per cent in that period.

### 3. Performance Measures

There are many possible measures of the quality and impact of science and scholarly inquiry. Two commonly used are summarized here: bibliometric analyses of publication counts in indexed journals and profiles of major prizes and awards. Canada's publication output is growing, but, according to a December 2016 update from the Council of Canadian Academies: "Production of publications in most fields of research in Canada grew more slowly than the world average in 2003–2014. This is a change from the 2012 report, which noted that half of the fields grew more quickly than the world average in 1999–2010." As a result, Canada's global rank in total research output dropped, from seventh in 2005–2010 to ninth in 2009–2014, as Italy and India moved ahead. Examining numbers of recent publications in *Nature* and *Science*, the two flagship journals of basic research, Canada ranked 8<sup>th</sup> among nations, with only 1 Canadian institution in the top 20 worldwide, and 2 more in the top 100.

Citations, which occur when publications are referenced in articles by other scientists and scholars, are a proxy for impact of Canadian-authored work. Canadian papers were cited at a rate 43 per cent higher than the global average in 2009–2014, standing commendably in the top six nations globally. However, our growth rate ranked 15<sup>th</sup>, suggesting again that Canada is stalling relative to peers. Examining the numbers of publications in the top 1 or 10 per cent worldwide for frequency of citation, on a per capita basis Canada lags other small nations such as the Netherlands, Sweden, and Switzerland.

Canada's performance in winning international prizes is trailing traditional powerhouses such as the U.S. and U.K. It is also well behind Australia, which now outperforms Canada on several other measures. In recent decades, twice as many Canadians have won research-related Nobel prizes while working in the U.S. as have been awarded to Canadian-born or foreign-born scientists working in Canada.

### 4. Findings and Recommendations in Brief

We emphasize that the summary of findings and recommendations below is highly abbreviated. It would be irresponsible for any secondary summary or other interpretation of our report, let alone policy action, to depend solely on this précis rather than on careful reference to the full text.

## 4.1 Broad Oversight, Rigorous Evaluation

Based on consultations and its own research, the Panel concluded that Canada's federal research ecosystem, despite many strengths, is weakly coordinated and inconsistently evaluated, and has not had consistent oversight. Further, the links between extramural and intramural research should be strengthened, as should federal-provincial-territorial (FPT) collaboration. The current external advisory body, the Science, Technology and Innovation Council (STIC), has no independent reporting authority and a constrained disciplinary mandate. The imminent appointment of a new Chief Science Advisor (CSA) for Canada is a major step forward, but more needs to be done.

We recommend **(R4.1)**<sup>ii</sup> that the Government of Canada, by an Act of Parliament, should create a new National Advisory Council on Research and Innovation (NACRI) to provide broad oversight of the federal research and innovation ecosystems. STIC should be wound down as NACRI is established **(R4.2)**.

NACRI should have 12 to 15 members, appointed through Orders in Council, comprising distinguished scientists and scholars from a range of disciplines as well as seasoned innovators with strong leadership and public service records from the business realm and civil society. Domestic members should be drawn from across Canada and reflect the nation's diversity and regions **(R4.3)**. An external member should hold the Chair of NACRI with the CSA serving as Vice Chair. NACRI should be supported by a dedicated secretariat working within the larger expert team supporting the CSA **(R4.4)**.

As a council of senior volunteers with a broad mandate of national importance, NACRI should have a publicly acknowledged working connection to the Prime Minister/PMO, parallel to that established for the CSA. NACRI should report to and interact most directly with the Minister of Science and the Minister responsible for Innovation and Economic Development, and liaise closely with the Minister of Health given Health Canada's linkages to CIHR. It should also have open channels of communication with ministers of key departments involved in intramural and extramural research **(R4.6)**. Connections to officials in Finance will be particularly important to facilitate input by the CSA/NACRI on intramural and extramural research budgets.

Among NACRI's responsibilities would be:

- advice to the Prime Minister and Cabinet on federal spending as well as broad goals and priorities for research and innovation;
- improving the coordination and strategic alignment of different elements of federal support for research and innovation;
- evaluation of the overall performance of the extramural research enterprise;
- public reporting and outreach on matters determined by the Council;
- confidential or public advice on other matters as requested by the Government of Canada;
- a foresight function for research and innovation;
- in concert with the CSA, ongoing advice on (i) the effectiveness of extramural research agencies and the intramural research groups, and (ii) the facilitation of collaboration among them and with the extramural research realm;
- advice on unusual requests for research support that fall outside the usual remit of the granting councils and CFI; and
- liaison with parallel bodies in provinces and territories and internationally as appropriate.

ii R4.1, etc. correspond to Recommendation 4.1, etc. in our report.



A relatively recent development has been the growth in numbers of “contribution agreements” whereby the Government of Canada channels research funds through or directly into external entities (e.g., Genome Canada or Mitacs). We did not review specific entities in detail, but believe more rigorous reviews should be undertaken before agreements are renewed. The Panel therefore recommends **(R5.8)** that NACRI be mandated not only to review proposals to create new third-party delivery organizations, but also to guide the periodic review processes for all existing third-party organizations, and advise as to the continuation or modification of their contribution agreements. As well, the Panel applauds the success of these entities in leveraging research funds, but recommends careful oversight of the implications of placing matching requirements on the funding of independent research **(R5.9)**.

A more interconnected intramural research realm is important both for sound policy formulation and for collaboration with extramural researchers. The Panel accordingly recommends **(R4.5)** that the Privy Council Office, working with departmental officials and the newly appointed CSA, examine mechanisms to achieve improved whole-of-government coordination and collaboration for intramural research and evidence-based policy-making.

As well, many informants recommended that the federal government should manage its investments in Big Science in a more coordinated manner. The Panel agrees. We recommend **(R4.7)** that the CSA convene a Special Standing Committee on Major Research Facilities (MRFs), chaired by an eminent scientist. This body would provide advice on the life cycle of federally supported MRFs, extending from a peer-reviewed decision to initiate an MRF, through budgeting, planning, and construction, then periodic reviews of effectiveness, and finally a decommissioning plan. Our report offers advice on the structure of the committee, its intersection with NACRI, and a tentative list of major science initiatives (MSIs) that might be considered to fall into the MRF category. This expert group would also improve decision-making about Canada's participation in global science initiatives, such as major astronomical telescopes.

Strong FPT collaboration is essential if Canada is to compete internationally. The Panel learned that interactions among the relevant officials and ministers are sporadic. Among the issues that seem likely to benefit from enhanced dialogue are matching requirements, human resource planning for research and innovation, and the institutional costs of research.<sup>iii</sup> We accordingly recommend **(R4.8)** that the CSA, with advice from NACRI, take the lead in promoting a shared agenda on matters of national concern. Ongoing interactions and annual in-person meetings should be established to strengthen collaborative research relationships among FPT departments with major intramural or extramural research commitments.

This is a special year for Canada. In that spirit, we recommend **(R4.9)** that the Government of Canada propose and initiate planning for a First Ministers' Conference on Research Excellence in 2017, both celebrating and cementing a shared commitment to global leadership in science and scholarly inquiry as part of Canada's sesquicentennial celebrations.

## 4.2 The Four Agencies: Strengthened Core, Better Coordination

The granting councils and CFI have made a vital contribution to Canadian science and scholarly inquiry. However, while assorted self-commissioned evaluations have occurred, the Panel could not find any broad external review of the federal agencies and research ecosystem since the 1970s. It is perhaps unsurprising that the Panel heard and read concerns about coordination, governance, strategy, budgeting, and programming. For example, while there is some apparent congruence in the conceptual basis of the Discovery (NSERC), Insight (SSHRC), and Foundation (CIHR) programs, success rates, funding levels, and peer review practices have all diverged across those programs to a degree that is hard to explain based on disciplinary differences alone.

<sup>iii</sup> This latter group of costs is sometimes (inaccurately) termed “indirect costs”; we believe, however, that the term, “facilities and administration costs” (F&A costs), better captures the direct financial impact of these activities.



There have been encouraging but piecemeal efforts to improve coordination, promote collaboration, and share best practices. However, the inconsistent governance of the agencies means that these have been highly dependent on the preferences of agency presidents. To improve this situation, the Ministers of Science and Health should **(R4.10)** mandate the formation of a formal coordinating board for the four agencies, chaired by the CSA, with membership including agency heads, department officials, and external experts. Reporting to the Ministers of Science and Health, the new Four Agency Coordinating Board would expeditiously determine and implement avenues for harmonization, collaboration, and coordination of programs, peer review procedures, and administration. In the event that the CSA and NACRI determine that progress on a shared agenda is unduly slow, the Board's composition would be revised and its authority extended such that its decisions would be binding for coordination of the agencies.

The Panel identified several areas that require the early attention of the new Board and the four agencies. Elimination of mandatory retirement has led to an aging of the professoriate, and is likely to constrain opportunities for early career researchers (ECRs) over the next decade. We also observed that the prospects for ECRs vary across the three granting councils, not only creating a demographic deficit, but also impeding the progress of women and other underrepresented groups that are more prevalent in the next generation, e.g., Indigenous people, those with disabilities, and members of racialized groups. Peer review practices vary, the program landscape is cluttered, and inefficiencies were identified by researchers in the organization and administration of grant competitions.

We accordingly recommend **(R5.2)** that the Government of Canada direct the new Coordinating Board to develop and harmonize funding strategies across the agencies, using a lifecycle approach that balances the needs and prospects of researchers at different stages of their careers. The four agencies should examine best practices in supporting ECRs, augment their support of ECRs at consistent levels across disciplines, and track and report publicly on the outcomes **(R5.6)**. The Board should **(R5.3)** also create a mechanism for harmonization as well as continuous oversight and improvement of peer review practices across the three councils and CFI, starting with a common set of guiding principles or values for peer review.

A further priority should be **(R5.4)** the development of consistent and coordinated policies to achieve better equity and diversity outcomes in the allocation of research funding while sustaining excellence as the key decision-making criterion. On this latter point, given experience with unaddressed gender bias in allocation of both Canada Research Chairs (CRCs) and Canada Excellence Research Chairs (CERCs), the federal ministers responsible should consider hard equity targets and quotas where inexplicable discrepancies persist **(R5.5)**.

Approximately 1.5 million Canadians have Indigenous roots, but the participation of this community in science and scholarly inquiry continues to be limited. As a small nation, Canada cannot compete globally in any realm without strong participation by all communities. The three granting councils should **(R5.7)** accordingly collaborate in developing a comprehensive strategic plan to promote and provide long-term support for Indigenous research, with the goal of enhancing research and training by and with Indigenous researchers and communities. The plan should be guided by the Truth and Reconciliation Commission's recommendations on research as a key resource.

The Panel also examined the legislative history, governance, and mandates of each of the four agencies. CFI functions as an independent non-profit with the president accountable to a corporate board, and the entire operation subject to a contribution agreement. If CFI moves from intermittent contributions to a regularized A-base budget, as recommended below, its governance will need to be revised. NSERC, SSHRC, and CIHR are all departmental corporations with advisory councils. Whereas SSHRC and NSERC have skeletal legislated mandates, the CIHR Act embodies an expansive and detailed mandate. Accountabilities for the tri-council presidents are less than clear.

The Government of Canada should (**R4.11**) undertake a comprehensive review to modernize and, where possible, harmonize the legislation for the four agencies that support extramural research. The review would clarify accountabilities and selection processes for agency councils and presidents, promote good governance and exemplary peer review practices, and give priority to inter-agency collaboration and coordination. On this last point, the goal must be to strengthen linkages between agencies, and not to thicken the walls of silos. Initiation of the Four Agency Coordinating Board should precede any legislative review.

Last, the Panel considered the thorny issue of allocation of funds across the three granting councils. We found no logical consistency to the current allocations but it is clear that all three councils are currently underfunded. CIHR's expansive mandate is not appropriately supported; its budget is sharply lower on a per capita basis than the counterpart U.S. National Institutes of Health, even taking into account the standard differences in funding models between U.S. and Canadian agencies. NSERC has a larger weighting of innovation-facing or priority-driven programming. While it does have much higher approval rates than the other councils for its flagship Discovery program, funding constraints above all have held the average size of those grants at a seriously suboptimal level for 15 years. Despite claims that funds are allocated on a 40-40-20 basis across the councils, SSHRC's share has been under 15 per cent for three decades. It has the largest constituency of faculty-level researchers, but over half of its funding goes to graduate awards. Its share of tri-council funding is likely to fall owing to its minimal participation in the large-scale Canada First Research Excellence Fund (CFREF) launched in 2015.

The Panel sees a period of reinvestment as the right moment for NACRI to review the allocation of new funds across the granting councils and recommend changes as appropriate (**R5.1**). Particular attention should be paid to evidence that the structures of tri-council programs have adversely affected the funding opportunities for scholars in the social sciences and humanities.

## 4.3 Strategic Clarity and a Multi-year Plan for Renewal

The Panel's overall conclusion is that independent science and scholarly inquiry have been underfunded for much of the last decade, as the federal government has concentrated resources on innovation-facing and priority-driven programs. In reaching that conclusion we considered the small and declining share of HERD attributable to the federal government; Canada's anomalous dependence on institutional subsidies to carry the extramural research enterprise; and our declining research performance on multiple measures, as compared not just with traditional powerhouses, but with smaller nations such as Australia and the Netherlands. We weighed temporal trends in per researcher funding, the demographics of the research community, Canada's density of full-time researchers and senior research trainees, and, not least, the distressingly low success rates (CIHR) and persistently low funding levels (NSERC, SSHRC) in the granting competitions that support independent research. We have no doubt that a major boost to funding for the ecosystem is urgently needed, with shortfalls affecting research operating grants, personnel awards, reimbursement of the institutional costs of research, and operations and maintenance of specific types of facilities.

### 4.3.1 Direct Project Funding: Research Operating Grants

The Panel's single most important recommendation (**R6.1**) is that the federal government should rapidly increase its investment in independent investigator-led research to redress the imbalance caused by differential investments favouring priority-driven targeted research over the past decade. The recommended investment is \$485 million, phased in over four years, directed to funding investigator-led research. This is an increase of about 30 per cent on the \$1.66 billion envelope currently committed to direct project funding for both priority-driven and investigator-led research. This would move the balance of funding within this envelope a meaningful distance back towards the 70:30 ratio in favour of investigator-led research that prevailed in the

early 2000s. The lion's share of this amount, \$405 million a year, would be devoted to the granting councils' core "open" competition programs. While the remainder would support investigator-led projects, it would be channelled to promote the emergence of a more vibrant research ecosystem by encouraging international collaborations, multidisciplinary work, high-risk ventures, and projects requiring rapid response. These are examined, in turn, below.

The Panel also examined the configuration of two priority-driven programs that, while constrained in key respects, provide operating funds to coalitions of frontline researchers. Each aims to create critical mass in a different way. The "classic" element (\$62 million per year) of the Networks of Centres of Excellence (NCE) suite of programs draws together researchers from multiple institutions. It imposes requirements for knowledge translation and commercialization that preclude or limit the creation of national networks of independent researchers, especially those working in basic research and, to some extent, in the social sciences and humanities more generally. CFREF is a newer program that aims to promote institutional specialization; some limited inter-institutional networks emerged in the second round of funding, but its strategic intent is one of local critical mass rather than national capacity. The concentration of funds is significant, approximating \$200 million per year flowing into a limited number of centres for research in specific areas aligned with the previous government's science and technology priorities.

The Panel sees these two strategies as complementary over time, but recommends refinements in one case, and a mid-course evaluation for the other. In particular, the Government of Canada should **(R6.2)** direct the new Four Agency Coordinating Board to amend the terms of the NCE program so as to include the fostering of collaborative multi-centre strength in basic research in all disciplines. This would mean, *inter alia*, removing requirements for knowledge "exchange and exploitation" and expectations of funding self-sufficiency for some competitions. For CFREF, the Panel recommends **(R6.3)** that an interim evaluation be undertaken before the third wave of awards is made. The CSA and NACRI should be engaged in the design of the review.

There are also four areas where operating grants are being made on an ad hoc basis. The Panel believes that these areas require a more systemic and coordinated approach, supported by earmarked funding.

First, international collaborations have become the norm in research. A stronger mechanism is needed for funding smaller- and mid-scale collaborative projects so that Canadian agencies and researchers can be more effective partners and participants in global science and inquiry **(R6.4)**.

Second, multidisciplinary research continues to grow in prevalence and importance. The councils have taken steps to support some joint initiatives, but the Panel believes that more must be done—not only to welcome and fairly review multidisciplinary proposals, but also to ensure that individuals working in convergent fields (e.g., health law, medical anthropology, design) are not orphaned **(R6.5)**.

Third, the councils should **(R6.6)** develop a coordinated strategy for adjudicating and supporting high-risk, high-reward (HR<sup>2</sup>) research. Other jurisdictions have successful HR<sup>2</sup> programming from which Canada should learn.

Fourth and finally, crises and urgent issues may occasionally require rapid responses by the research community. These needs have been accommodated in an ad hoc fashion in recent years, but a more formal process involving the CSA would be appropriate today **(R6.7)**.

The required funds for these four areas can arguably be aggregated in one or two contingency pools. Given extant funding pressures and challenges in the governance and oversight of the councils, we recommend that a portion of the base increase of \$485 million be earmarked for these purposes, starting at \$20 million in base funding in the first year, and rising progressively to a steady-state of \$80 million per year over four years, with early priority given to strengthening international collaboration.

### 4.3.2 Infrastructure

CFI confers distinct strategic advantages on Canadian research by depoliticizing research infrastructure decision-making. It functions as a core agency, but is governed by contribution agreements with a separate non-profit corporate structure because it originally received and held unspent year-end funds. The federal government terminated that funding model, and CFI has since been funded by large and intermittent one-time-only allocations that it deploys over some years. The resulting saw-tooth pattern of funding impedes planning and coordination. Continued A-base funding would be budget neutral.<sup>iv</sup> The Panel recommends **(R6.8)** that the Government of Canada shift CFI to a stable annual budget scaled at minimum to its recent annual capital commitment (currently around \$300 million per year). This shift would likely require governance changes, covered as part of the four agency review recommended above **(R4.11)**.

The need for further growth in CFI's capital fund should be monitored. However, the Panel observes that the relevant sectors have benefitted both from the Knowledge Infrastructure Fund (2009–2011) and the ongoing Post-Secondary Institutions Strategic Investment Fund (2016–2018).

CFI's institutional operating and maintenance (O&M) outlays are provided through its Infrastructure Operating Fund and scaled to recent capital awards. These one-time allocations serve more as a pool of funds in support of start-up costs than as a continuing offset of the institutional costs of research. We address those liabilities below.

As contrasted with the one-time O&M support to institutions, CFI since 2010 has provided ongoing funding to a number of MSIs. The MSI funding mirrors CFI's capital ratio (40:60) for matching of eligible O&M costs. A number of national-scale MSIs are struggling to meet this matching requirement. We have recommended **(R4.7)** above) additional oversight for these MRFs with a view to averting future problems, but these national facilities are unfortunately at immediate risk. We therefore recommend **(R6.10)** that the federal government mandate and fund CFI to increase its share of the matching ratio for national-scale MRFs from 40 to 60 per cent. The annual cost of doing so is estimated at \$35 million.

One other element of infrastructure that drew our attention relates to the digital research realm. There are many players active here, and an effort is underway to develop a coordinated plan through the Leadership Council on Digital Infrastructure. The two cornerstone organizations receiving federal funding are Compute Canada and CANARIE. We recommend **(R6.9)** that the Government of Canada merge these organizations and provide the new entity with consolidated long-term funding and a mandate to lead in refining and implementing a national digital research infrastructure (DRI) strategy.

### 4.3.3 Personnel

#### *Support for Doctoral Students and Postdoctoral Fellows.*

Doctoral students and postdoctoral trainees or fellows (hereafter PDFs) are integrally involved in the majority of postsecondary research in Canada. The recommended increase in support for independent investigator-led funding will enhance stipendiary support and enrich the training environment for graduate students and PDFs across the ecosystem. However, while these and other sources of support (institutional, provincial, industrial, and charitable) underwrite most of the relevant salaries and awards, we estimate that over 6,000 doctoral students and 1,400 PDFs across Canada hold direct federal awards at any time. These awards set a bar for funding and quality.

The number of core graduate awards (Canada Graduate Scholarships) has not increased since 2007 despite major increases in graduate enrolments. In addition, the value of graduate awards has not changed since

<sup>iv</sup> CFI does not currently have continuing A-base funding, but the Department of Finance makes provision for its ongoing expenditures. As we are recommending that CFI spending on capital continue at recent activity levels, this recommendation is budget neutral.

2003, and PDF awards levels are similarly lagging, not least in comparison to U.S. rates. There is also a puzzling mix of council-specific and tri-council awards, with variation in value, duration, and international portability. The complexity was augmented in 2008 and 2010 with the addition of smaller numbers of more remunerative awards to doctoral students (Vanier) and PDFs (Banting), respectively. These are flexible as regards recruitment of international students or international placements for domestic students, but their numbers are small. A clear strategy is needed to increase the recruitment of top-flight international graduate students and PDFs, and to ensure that more domestic students and trainees have opportunities to learn from international exposure to leading scientists and scholars.

We recommend **(R7.1)** that the Four Agency Coordinating Board be directed to oversee a tri-council process to reinvigorate and harmonize scholarship and PDF fellowship programs, and rationalize and optimize the use of current awards to attract international talent. While strict uniformity may be neither feasible nor desirable, more consistent and, in many cases, more generous levels of support (value and duration) are needed. We undertook benchmarking to estimate the financial implications of harmonizing, upgrading, and bringing strategic focus to the system of graduate student and PDF supports. As a result of these analyses, we recommend that a total base increase of \$140 million per year be phased in over four years, in equal increments of \$35 million per year.

### *Research Chairs for Excellent Scholars and Scientists*

The major sources of federal funding for researcher salary support are the CRC and CERC programs. Launched in 2000, the CRC program aimed “to attract and retain some of the world’s most accomplished and promising minds” by creating 2,000 research professorships across Canada. Chairs are allocated to institutions based on shares of competitive grant funding received from the three councils. Tier 1 Chairs, valued at \$200,000 per year, are intended for researchers recognized as world leaders in their fields and renewable on seven-year terms. Tier 2 Chairs, valued at \$100,000 per year, target exceptional emerging researchers, and can be renewed once with a five-year term. The value of these awards has not changed for 17 years.

The CERC program was established in 2008 to “support Canadian universities in their efforts to build on Canada’s growing reputation as a global leader in research and innovation.” It awards world-renowned researchers and their teams up to \$10 million over seven years to establish ambitious research programs at Canadian universities. The 27 CERCs awarded to date are non-renewable and require 1:1 matching funds from the host institution. All CERCs have been recruited from abroad. All, until the most recent round, have been constrained to the government’s STEM-related priorities, restricting their availability for scholars and scientists from the SSHRC-supported disciplines.

A 2016 evaluation of the CRC program observed that a rising number of chairholders originated from within the host institution, with a further 14.4 per cent recruited from other Canadian institutions. For the 2010–2014 period, international recruits accounted for only 13 per cent and 15 per cent of new Tier 1 and 2 nominees, respectively, whereas in 2005–2009, the averages were 32 per cent and 31 per cent, respectively.

Due to turnover and delays in filling Chair positions, approximately 10 to 15 per cent of Chairs are unoccupied at any one time. As a result, the CRC program’s budget was cut by \$35 million in 2012. This predictably drove numbers down further, with an all-time low of only 1,612 Chair positions (80.6 per cent of the original plan) filled as of December 2016.

This flagship program is vitally important to Canada and requires major renewal. We recommend **(R7.2)** a three-stage process. First, funding of the overall program should be restored to 2012 levels (a \$35 million base commitment), but only after the granting councils and Chair Secretariat produce an approved plan for (i) allocating the new Chairs asymmetrically in favour of Tier 2 awards to help ECRs, and (ii) improving logistics in managing numbers and reducing delays in awarding Chairs so as to improve the uptake of available funds.

Second, the granting councils should be directed to cap the number of renewals of Tier 1 Chairs, and develop a plan in concert with universities and CFI to reinvigorate international recruitment and retention.

Third, once that plan is reviewed by NACRI and approved by the government, the value of the CRCs should be adjusted to account for their loss in value due to inflation since 2000 (estimated cost of \$105 million). Staged over two to three years, the total cost is approximately \$140 million.

The disciplinary distribution of CRC awards should be re-examined *pari passu* with the review recommended in **R5.1**. Closer scrutiny of internal nominations is needed to ensure that they reflect proven retention priorities. We also support setting specific targets for international recruitment, as recommended by the recent CRC evaluation.

Last, the Panel heard many concerns about the relative value of the CERC awards, and the uncertain sustainability of programs that focus such substantial resources around a single international recruit. The Panel acknowledges the quality of the CERCs who currently hold these awards, and the need for high-value awards to attract the brightest and best from around the world. However, the extant evaluations are not adequate. A detailed review of the relative cost-benefit of the CERC versus CRC programs should be undertaken in 2017 to determine where the investments should be directed for the greatest impact.

If the renewal of the CRC program is not sufficient in itself to improve international recruitment, then specific modifications of the program to that end may be a more sustainable strategy than the CERCs currently are likely to provide.

#### 4.3.4 Facilities and Operations

The CFI Infrastructure Operating Fund (IOF) provides a one-time payment equivalent to 12 per cent of the total capital. This treatment contrasts with the partial funding of ongoing operating costs as is provided for MSIs. The large shortfall in coverage of the institutional costs of research means that these funds are not always available to individual researchers and teams that rely on small-scale equipment, leading to a productivity drain. The Government of Canada should (**R6.11**) accordingly mandate and fund CFI to meet the special operating needs of individual researchers with small capital awards. We benchmarked this need and estimated that approximately \$30 million per year earmarked for the relevant awardees would ensure continuity of operations. To facilitate rapid implementation of this recommendation, this amount should be offset against recommended increases to the Research Support Fund (RSF) to render it costless to the federal government.

The much larger issue is strengthening the overall institutional fabric of Canadian research. All postsecondary research depends upon maintaining common-use equipment; meeting regulatory standards; regularly upgrading institutional computer services; keeping libraries stocked; cleaning, lighting, and heating laboratories and research space; and administering grant awards. Additional costs relate to funding the protection of intellectual property and the commercialization of technologies arising from the research. Two programs (CRCs and CFREF) allow the research grants themselves to cover a limited number of these charges. For the vast majority of research operating grants, no budget lines for F&A costs are allowed, and a separate program, the RSF, instead offers partial reimbursement. The current reimbursement level averages 21.6 per cent of eligible direct operating costs of grants and is formulaic and arbitrary. In contrast, the F&A reimbursement range for U.S. institutions is based on actual audited costs, and typically runs from approximately 40 to 60 per cent. Canadian institutions that have submitted detailed F&A expenses to U.S. funders are reimbursed at an average of 49.3 per cent. As a further example within Canada, the Government of Quebec has a sophisticated system of provincial research grants, and provides 60 per cent coverage for “heavy” or *lourde* research disciplines (e.g., medicine, engineering, chemistry) and 45 per cent for “light” or *légère* disciplines (e.g., history, psychology, communications).

Institutions of higher learning are absorbing these F&A costs by using tuition dollars and provincial grants that should be dedicated to their teaching and learning mission. Greater success in winning federal research funding leads to more intense budgetary pressure on the teaching and learning mission—a counter-productive arrangement.

The federal government's underfunding of F&A costs can also be linked to complaints that the Panel heard from researchers about the challenges in keeping equipment in top operating shape, and their frustration with obtaining adequate assistance for administration of research grants. Moreover, to be effective partners in innovation, universities must engage in knowledge translation, manage intellectual property, and partner with for-profit and non-profit enterprises. Without comparable levels of F&A funding, Canadian institutions will never be able to compete successfully with the technology transfer record of U.S. universities.

A further concern is that the RSF formula operates on a reverse income tax model that sees smaller institutions paid first at rates of between 40 to 80 per cent with the remainder of the funds distributed by equal proportion to institutions receiving more than \$7 million a year in research funding. This helps small institutions cope with higher F&A costs due to diseconomies of scale. Concerns about the formula therefore focus on the fact that larger institutions are perversely penalized for success. However, the decline in reimbursement is actually fastest for smaller universities in a growth phase between \$7 million and \$30 million. The current RSF accordingly penalizes the “gazelle” institutions where research activities grow fastest in future.

The federal government currently pays about \$369 million per year through the RSF on eligible grants totalling \$1.708 billion (21.6 per cent). To take the current rate to 30 per cent would add approximately \$143 million to the tri-council base. The corresponding numbers for 35 per cent and 40 per cent are \$229 million and \$314 million.

The Government of Canada should take immediate steps to reduce this accumulated and growing liability and to obtain a proper return on its research investments. Given the size of the shortfall and the priority that must be given to new operating grants for independent research, a staged approach would be needed to improve F&A reimbursement rates across both existing and new RSF-eligible grants. The recommended target (**R7.3**) is a reimbursement rate of 40 per cent for all institutions with more than \$7 million per year of eligible funding. Current thresholds should be maintained to enable additional support for smaller institutions. As the size of the envelope of RSF-eligible operating grants grows, the funding of the RSF should be increased in lock-step to sustain the reimbursement rate of F&A costs on a trajectory towards this 40 per cent goal.

As the program moves to more adequate levels of reimbursement, closer oversight and reporting will be required. Phased growth in reimbursement rates has the advantage of offering time for the granting councils, CFI, and RSF Secretariat to work with universities and research institutes on mechanisms that ensure full transparency for the use of these funds, with priority given to expenditures that improve the daily productivity and ongoing success of Canadian scientists and scholars.

Last, the federal government's RSF strategy represents rational leverage. Federal grants are eagerly sought and welcomed by researchers; institutions, provinces, benefactors, and fee-paying university students have continued for decades to subsidize the federal research efforts. However, while this has allowed the federal government to sustain a leadership role based on fractional funding in an area of shared jurisdiction, it has also adversely affected the funding of the teaching and learning mission of the nation's universities, and constrained the quality of the research environment for our scholars and scientists. We applaud federal leadership as essential but believe that, at 23 per cent of overall HERD spending, the Government of Canada's fractional funding has fallen to unsustainable levels. Failure to act on this issue, in concert with improvements in direct funding of operating grants, will also, for reasons given, sharply worsen the situation. In brief, augmenting F&A reimbursement rates is an essential part of our plan.



## 5. Conclusion

We conclude that the recent erosion of Canada's research competitiveness is linked to changes in federal funding for extramural research that have both constrained funding per researcher, and directed funding preferentially to priority-driven and partnership-oriented research. The situation has been exacerbated by a policy shift in favour of new programs that focus resources on a limited number of individuals and institutions, without commensurate reinvestment to lift frontline research more broadly or sustain the value of existing programming. While Canada's HERD ratio is high, federal sources account for less than 25 per cent of total HERD, and we are now an outlier among nations in the extent to which institutions underwrite the costs of research.

These challenges have been exacerbated by suboptimal coordination and collaboration among the four pillar agencies. The variations in governance, administrative practices, and funding priorities within and across agencies cannot be explained by disciplinary differences or by the needs of the relevant research communities.

We have accordingly recommended substantial improvements in governance, oversight, and advice. These include creation, by legislation, of an independent National Advisory Council on Research and Innovation. NACRI in tandem with Canada's new CSA would advise on evaluations for all programming in both the research and innovation spheres, including proposals for new agreements with external entities and renewals of extant agreements. An external expert group should be convened by the CSA to improve the oversight of national-scale MSIs. The Panel has also recommended wide-ranging improvements to oversight and governance of the four agencies, including the appointment of a Four Agency Coordinating Board chaired by the CSA. The Board would play a key role in driving a number of priorities identified in the report, targeting the effectiveness, accountability, efficiency, and equity of various elements of the system.

Concurrent with these changes to governance and improvements to accountability, major reinvestments are urgently required. We envisage a four-year phase-in involving base increases averaging 9 per cent each year. Many of the specific increases are contingent on approval of plans to ensure efficient use of new funds. New spending would be balanced across:

- investigator-led research operating grants (the highest priority);
- enhanced personnel supports for researchers and trainees at different career stages;
- targeted spending on infrastructure-related start-up (small equipment) and operating costs (Big Science facilities); and
- enhancement of the environment for science and scholarship by improved coverage of the institutional costs of research.

The cumulative base increase would move annual spending in steady-state across the four agencies and related entities from approximately \$3.5 billion to \$4.8 billion. The steady-state increase in base by the end of four years amounts to 0.4 per cent of the Government of Canada's annual budget. This commitment would both affirm renewed federal leadership and greatly strengthen the foundations of Canadian research. Given global competition, the role of research in underpinning innovation and educating innovators, the need for evidence to inform policy-making, and the current unsettled conditions in the research ecosystem, the Panel firmly believes that this commitment is also among the very highest-yield investments in Canada's future that any government could make.