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GOVERNMENT POLICIES TO ENCOURAGE UNIVERSITY-BUSINESS RESEARCH COLLABORATION IN CANADA: LESSONS FROM THE US, THE UK AND AUSTRALIA

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Government Policies to Encourage University-Business Research Collaboration in Canada: Lessons from the US, the UK and Australia

ABSTRACT

This report reviews findings from the research literature on motivations for, barriers to, and determinants of university-business (U-B) research collaboration. It examines how U-B research collaboration is measured and Canada's international ranking. It describes public policy measures for encouraging U-B research collaboration in Canada and three reference countries – the US, the UK and Australia. Drawing on the results of this work, the report provides recommendations on how Canadian governments can strengthen their role and effectiveness as advocates, enablers, funders and rule-makers for U-B research collaboration.

RÉSUMÉ

Le présent rapport étudie les résultats du compte rendu de recherche portant sur la recherche collaborative université-entreprise (U-E), notamment sur les facteurs qui la favorisent, qui y constituent un obstacle ou qui sont déterminants de sa mise en place. Il examine la façon de mesurer la recherche collaborative U E ainsi que le classement du Canada à l'échelle internationale. Il décrit les mesures d'intérêt public visant à stimuler la recherche collaborative U E au Canada ainsi que dans trois pays de références – les É. U., le RU et l'Australie. En s'appuyant sur les résultats de cette recherche, le rapport fournit des recommandations sur la façon dont les gouvernements canadiens peuvent renforcer leur rôle et leur efficacité en tant que défenseur, facilitateur, investisseur et créateur de règles en matière de recherche collaborative U E.

Government Policies to Encourage University-Business Research Collaboration in Canada: Lessons from the US, the UK and Australia

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Government Policies to Encourage University-Business Research Collaboration in Canada: Lessons from the US, the UK and Australia

EXECUTIVE SUMMARY

The question of whether university-business (U-B) research collaboration is desirable has already been answered in the affirmative by many universities. U-B research collaboration by itself does not create good universities. But good universities are marked by their ability to attract businesses interested in accessing the knowledge, talent, and physical research infrastructure they possess. Conversely, U-B research collaboration by itself does not create competitive and profitable businesses. But many competitive and profitable businesses are marked by their interest and ability in accessing talent, ideas, and research facilities wherever they may be found, including at universities.

There are many reasons why governments in Canada and other countries are interested in encouraging U-B research collaboration. They see it as one way to: extract greater economic and social value from large and continuing public investments in education and research; bring the results of university based research more quickly to the marketplace and their citizens than might otherwise be the case; and open up new opportunities for universities to equip students with the skills and knowledge required to live and work in the twenty-first century. They believe it to be one means, although perhaps indirect, to strengthen the productivity of their business and social sectors and, through that channel, generate higher living standards for all. In the language of economists, governments recognize that U-B research collaboration can generate positive "spillovers" for society.

This report examines a range of indicators (see Exhibit I at the end of this Executive Summary) and finds that Canada is not significantly lagging other comparator countries in U-B research collaboration. But Canada is by no means a world leader in U-B research collaboration or in capturing all of its economic and social benefits.

- **The World Economic Forum's (WEF) survey of business opinion shows that Canada has climbed in the ranking of countries with extensive U-B research collaboration over the past several years, from 15th place in 2007 to 7th place in 2010**. But what comfort can Canadians take from this in light of the fact that Canada ranked in 6th place in the WEF's 2001 ranking of countries with extensive U-B research collaboration? (Exhibit I, indicators 1-3).

- **Canadian businesses spend relatively more on research conducted at universities than do their counterparts across the OECD after taking into account differences in the size of national economies.** The higher education sector in Canada performs 6.2 per cent of total business sector R&D, compared to 2.5 per cent in the UK, 2.1 per cent in Australia and 1.1 per cent in the United States. When measured as a share of GDP, business investment in university research is: 0.06 percent of GDP in Canada; 0.02 percent of GDP in the US and the UK, and 0.03 percent of GDP in Australia. Canada leads all major OECD economies measured by the percentage of total higher education expenditures on R&D (HERD) that is financed by business: 8.5 percent of HERD in Canada compared to 5.7 percent in the US; 4.6 percent in the UK; and 4.9 percent in Australia. (Exhibit I, indicators 4-6). But Canada cannot lay claim to a gold medal:

    - there are important technical issues relating to the comparability of the data sets;

    - Canadian business spending on university research has flatlined over the past decade. Statistics Canada reports that funding of HERD from the business enterprise sector increased slightly to C$ 892 million current dollars in 2008/2009 or 8 percent of the total share of R&D spending in the higher education sector. But in real dollars, taking into account inflation, the business enterprise sector's contribution dropped 1.3 percent to C$ 737 million; and,

    - there is little evidence to conclude that Canada outperforms other comparator countries in deriving economic and social value from business spending on university-based research. Internationally comparable indicators of technology transfer and commercialization of university research (e.g., patenting, licensing, invention disclosures, and university start-up companies), and even though they are widely acknowledged to be very narrow and limited when it comes to measuring U-B research collaboration and its results, suggest that, on balance, Canada is not marked as a world leader. (Exhibit I, indicators 8-14).

This report describes public policy measures being taken by governments in the US, the UK and Australia to encourage U-B research collaboration (Exhibit II at the end of this Executive Summary provides a table of the main policy directions and measures). The four main observations on the experience of these countries that can help inform future Canadian policy development are:

- Governments in all three countries are advocates for U-B research collaboration, but no national government is as loud an advocate as is the UK government. The *Lambert Review of Business-University Collaboration*, commissioned by the UK Treasury and published in 2003, provided UK businesses, universities and governments with a roadmap for strengthening U-B collaboration. However, during 2010 there emerged in the UK a growing sense that "more can be done." From this perspective, the UK Government's November 2010 *Technology Blueprint* may be seen as a new roadmap for U-B collaboration in the UK – one that ties U-B research collaboration more closely than ever before with UK innovation policy goals. **The lesson for Canadian governments is that advocacy of U-B research collaboration is an important role for government.**

- Governments in all three countries rely on a range of government research funding institutions, and are placing an increasing reliance on third-party institutions, to encourage U-B research collaboration. They have also designed tax incentives to encourage U-B collaboration but do not place great reliance on that policy instrument. Over the past decade, the Australian and UK governments have created organizations to centralize the delivery of funding programs to support the commercialization of research (as has the Government of Ontario through the arms-length and non-profit corporation OCE Inc.). They have also invested in many other organizations that help better connect universities and businesses. All three governments are strengthening their systems for public reporting on U-B collaboration in research and other areas. **The lesson for Canadian governments is that many policy instruments are available to better enable and fund U-B research collaboration: the lead funding institutions can be government departments and research councils but third party organizations can also be relied upon; funding of business research designed with encouraging U-B collaboration in mind can flow through direct spending or through the tax system; and what governments decide to measure and report to citizens – including in the area of U-B research collaboration performance – matters to the development of public policy and the exercise of national influence on the world stage.**

- Governments in all three countries, but particularly the US federal government, recognize that processes and structures for negotiating and managing intellectual property (IP) in university settings influence the form and extent of U-B research collaboration. The US is getting its own IP house in order even as a vigorous and fractious debate has emerged on whether an individual inventor or the institution in which he or she works should own IP resulting from federally funded research (there is now a case involving this subject before the US Supreme Court). A major study on managing university IP in the public interest has been conducted by the US National Academy of Sciences (NAS) and was released in September 2010. The NAS report identifies good practices for IP management by research institutions and contains recommendations on how the US federal government can play a stronger role in supporting their uptake**. The lesson for Canadian governments is that IP policies and management processes, including as they are found in university settings, can be turned into a competitive advantage and can drive the creation and diffusion of new knowledge – including through U-B research collaboration.**

- The US, the UK, and Australia have permanent national forums that bring together university and business leaders and that help strengthen the relationships between the two sectors: the Business Higher Education Forum in the US; the Council for Industry and Higher Education in the UK; and the Business-Higher Education Roundtable in Australia. None of these forums were initiated by government or funded by government to any large extent. Canada no longer has permanent, national, and "peak-level" forum of university and business leaders (a forum did exist ten years ago but has faded away apparently in a fit of absent-mindedness by Canadian university and business leaders). **The lesson for Canadian governments is that the creation and funding of national university-business forums should be undertaken by the two sectors themselves.**

This report contains five main recommendations for how the Canadian federal government can strengthen its role as advocate, enabler, funder and rule-maker for U-B research collaboration in Canada.

1. **The federal government should continue to provide direct funding to encourage U-B research collaboration at least up to current levels (estimated in this report as being over C$ 370 million annually) rather than enriching the existing Scientific Research and Experiment Development (SR&ED) tax credit specifically to incent businesses to allocate a higher proportion of their R&D spending to university research.**

2. **The federal government should examine the option of moving lead responsibility for many existing funding programs for U-B research collaboration and related commercialization activities to a single organization operating at arms-length from government. Such an organization could pursue tangible and unambiguous objectives that are grounded on real market circumstances and opportunities. It does not have to be "business-led" but must have business and university participation and support.**

3. **The federal government should review the role and effectiveness of intermediary organizations the sit between universities and business and which are increasingly important conduits for federal funding of U-B research and related commercialization activities. The review should address at least three questions: (1) are there significant gaps in sectoral or technological coverage or in the type of intermediation activities and services offered? (2) should longer-term financial support be provided to some of these organizations for some portion of their operational expenses? and (3) are they sufficiently transparent and accountable conduits for helping to assemble and flow public research dollars to U-B research projects?**

4. The federal government should lead a structured national discussion involving businesses, universities, and provincial governments on how to improve processes for the negotiation and management of intellectual property (IP) within university settings.

5. The federal government should issue a clear statement of its objectives and expectations for the future of U-B research collaboration in Canada that can both inspire and serve as a touchstone for measuring progress. However, the federal government should resist the temptation to take a leadership role in establishing or funding a new forum that brings together university and business leaders. Even though such forums exist today in the US, the UK and Australia, and have existed in Canada in the past, Canadian university and business leaders themselves must decide if such a forum is required and what useful functions it could serve.

Exhibit I: Table of Selected University-Business Collaboration Indicators

	INDICATOR	Degree of International Comparability	Canada	US	UK	Australia	Other Jurisdictions
1	**World Economic Forum country rankings on university-business (U-B) R&D collaboration.** Reference Period: 2010	High	**7**	**1**	**4**	**13**	**Switzerland: No. 2** **Finland: No. 3** **Sweden No. 5** **Singapore: No. 6**
2	**WEF ten year average score on U-B R&D collaboration (1= do not collaborate, 7 = collaborate extensively).** Reference Period: 2001-2010	High	**5.0**	**5.6**	**5.1**	**4.5**	**2001-2010 Average Score for Top 30 countries in 2010: 4.7**
3	**IMD World Competitiveness Yearbook Country Ranking on Knowledge Transfer between business and universities** Reference Period: 2010	High	**8**	**2**	**15**	**18**	**..**
4	**Share of total HERD funded by the business sector.** Reference Periods: 2008	Medium	**8.5%**	**5.7%**	**4.6%**	**4.9%**	**OECD: 6.2% (2007)**
5	**R&D funded by business sector and performed by higher education sector as percent of GDP.** Reference Periods: Australia 2008; all others 2007	Medium	**0.06%**	**0.02%**	**0.02%**	**0.03%**	**..**
6	**Share of total business sector R&D funding performed by the Higher Education sector** Reference Periods: Australia 2008-2009; all others 2007.	Medium	**6.2%**	**1.1%**	**2.5%**	**2.1%**	**..**
7	**Share of industry S&T papers written in collaboration with an academic institution.** Reference Periods: Canada (2005); US (2008)	Medium	**55.0%**	**53.8%**	**..**	**..**	
8	**University commercialization staff per US $100 million in research expenditures.** Reference Periods: Canada, US and Australia, 2008; UK 2005	Low	**7.9**	**5.0**	**19.6**	**8.6**	**..**
9	**Universities: invention disclosures per US$ 100 million in research expenditures in 2004**	Medium	**32.0**	**40.4**	**51.6**	**25.4**	**EU: 33.3**
10	**Universities: Patent applications per US$ 100 million in research expenditures in 2004**	Medium	**29.7**	**25.5**	**15.1**	**9.5**	**EU: 9.5**
11	**Universities: Patent grants per US$ 100 million in research expenditures in 2004**	Medium	**4.9**	**8.8**	**3.1**	**8.2**	**EU: 3.8**
12	**Universities: Licenses executed per US$ 100 million in research expenditures in 2004**	Medium	**11.3**	**11.0**	**36.7**	**9.5**	**EU 8.3**
13	**Universities: Start-up companies formed per US$ 100 million in research expenditures in 2004**	Medium	**1.5**	**1.1**	**2.8**	**0.8**	**EU 2.8**
14	**Universities: Licence Revenues as percent total university research expenditures in 2004**	Medium	**1.0%**	**2.9%**	**1.1%**	**1.8%**	**EU 1.2%**
15	**Number of SMEs collaborating in innovation with HE sector as percentage of all firms. Data for Canada and France covers manufacturing sector only.** Reference Periods: Canada, '02-'04; UK and other EU, 04'-'06; Australia, '06-'07.	Low	**4.2%**	**..**	**3.1%**	**3.1%**	**OECD: 3.9%** **Finland: 16.3%** **Austria: 6.9%** **France: 6.3%**
16	**Number of large firms collaborating in innovation with HE sector as percentage of all firms. Data for Canada and France covers manufacturing sector only.** Reference Periods: Canada ('02-'04); UK and other EU ('04'-06); Australia ('06-'07).	Low	**11.9%**	**..**	**9.4%**	**10.0%**	**OECD: 21.9%** **Finland: 59.1%** **Slovenia: 41.3%** **Austria: 35.8%**

<u>Sources and Notes</u>: See Annex V to this report.

Exhibit II: Summary of Policy Directions and Measures for Encouraging U-B Collaboration in Canada, the US, the UK and Australia

GOVERNMENT AS ADVOCATE	Canada	US	UK	Australia
Policy Statements, Strategies, and Reports	• U-B collaboration identified as a priority in most federal, provincial and territorial government innovation strategies (but positioned under the broader theme of "partnerships" in the federal S&T strategy). • The federal government appointed an Expert Panel to examine federal support for business and commercially related R&D in October 2010. It is scheduled to report later in 2011. Its public consultation paper asks: "What are the main impediments to successful business university or business-college partnerships? Does the postsecondary education system have the right capacity, approaches, and policies for effective partnerships with business?"	• State and local governments have taken lead in U-B research advocacy. But US federal government is ramping up its advocacy activities. • The US Office of Science and Technology and the US National Economic Council (both reporting directly to the US President) held public consultations on commercialization of federally funded research in 2010; • In 2010 the US Secretary of Commerce hosted regional forums (at major universities) on the commercialization of research. • The President's Council of Advisors on S&T provided the US President with a report on encouraging U-B collaboration in 2008.	• *Lambert Report* (2003) was launch vehicle and roadmap for mobilizing interest and attention of governments, businesses and universities. • In 2010, two major studies directly addressed emerging challenges in UK U-B research collaboration (Hauser and Dyson reports). They served as the basis for the UK Government's *Blueprint for Technology* (November 2010) and represent a renewal of the roadmap first set out in the *Lambert Report*.	• U-B collaboration identified as key area of economic importance to Australia in 2008 report to the Minister for Innovation, Industry, Science and Research (*Venturous Australia*). • U-B research collaboration identified as one of the top five priorities in federal government's 2009 *Powering Ideas* Innovation Agenda.

Exhibit II (continued)

GOVERNMENT AS ADVOCATE (continued)	Canada	US	UK	Australia
Changes to Government Organizations and Mandates	• Results of federal expert panel on federally funded research expected in 2011. • Several provinces have re-organized and rationalized their innovation policy departments and agencies, partly to position them as better advocates of U-B research collaboration and commercialization of results.	• National Science Foundation supported the creation of the University-Industry Demonstration Partnership (2004); • The US federal government has created an Office of Innovation and Entrepreneurship (2009) and an Advisory Council on Innovation (2010) – although both have broader mandates than just encouraging U-B research collaboration.	• Created the Technology Strategy Board (TSB) in 2004 to deliver major (not all) research funding programs to industry. TSB made an "arms-length from government" organization in 2007. • TSB mandate expanded in 2010 to include oversight of the new Technology and Innovation Centres and also some programs from UK Regional Development Agencies.	• Created and funded Business Industry Collaboration Council in 2004 but the organization closed its doors in 2008 as the end of government funding for its operations came into sight. • In 2010 created a new organization, Commercialisation Australia, the centralized the delivery of research commercialization programs.
U-B Advocacy Forums	• Canadian Corporate-Higher Education Forum (C-HEF) established by university and business leaders in 1983 but became inactive after 2000 for reasons that are not clear (perhaps no longer perceived as delivering value to university and business leaders).	• US Business Higher Education Forum (BHEF) established 1978 (not government sponsored). • US Council on Competitiveness includes business, university and labour leaders.	• UK Council for Industry and Higher Education established in 1986 and its membership includes representatives from the UK Government's Higher Education Funding Councils. • The major UK business association (CBI) includes university relations unit.	• Australia's Business Higher Education Roundtable (B-HERT) established in 1990 Not government funded but membership includes public research organizations (e.g., the Commonwealth Scientific and Industrial Research Organization).

Exhibit II (continued)

GOVERNMENT AS ENABLER	Canada	US	UK	Australia
Support for Intermediary Organizations that Connect Universities and Businesses	• Federal and provincial governments provide considerable financial support (although varying in quantity and duration) to a growing number of organizations that function to connect business and university research communities. • MaRS Discovery District has put Canada on international map. Many other success stories (Precarn, CMC Microsystems, Canada Mining Innovation Council, Innovacorp, PROMPT, and OCE Inc. are a few among many examples). • Support also provided to national and regional networks for research commercialization.	• US federal government provided start-up funding in the 1980s for several organizations in import vulnerable areas (e.g., semiconductors and advanced manufacturing) • Many of these organizations continue to be: important conduits for federal research funding of U-B research. Several (e.g. the Semiconductor Research Corporation and the National Center for Manufacturing Sciences) connect US business with talent and resources not only at US universities, but also with universities around the world. • There are a number of world-renowned state and local organizations (e.g. the Georgia Research Alliance and San Diego CONNECT).	• Run-up to the election of Coalition Government accompanied by major re-think of government support for intermediary institutions (Dyson and Hauser reports). • In November 2010 the UK Prime Minister announced £ 200 million investment (over five years) in Technology and Innovation Centres (TIC) that will "sit between universities and businesses, bringing the two together." Priority has been given to establishing a first centre in the area of high value manufacturing.	• Federal government's 2008 *Enterprise Connect* program includes an A$ 250.7 million investment in intermediary organizations (six manufacturing centres and six innovation centres). • The Australian Rural Research Development Corporations (RDCs), which receive federal and state funding but are also funded by a system of industry levies, are a distinctive model for meeting "demand driven" agricultural research needs and connecting university and other public researchers to agricultural producers.

Exhibit II (continued)

GOVERNMENT AS ENABLER (continued)	Canada	US	UK	Australia
Leveraging Government Research Assets	• The National Research Council's research institutes are already often co-located with, or adjacent to, universities. • A federal government report (Naimark, 2008) identified opportunities for co-locating and otherwise leveraging other federal research assets, but no formal federal government response or action plan has been issued. • Re-location (between 2007 and 2010) of the Department of Natural Resources' Materials Technology Laboratory from Ottawa to McMaster Innovation Park in Hamilton, Ontario, is an example of what can be done (at a cost of C$ 6 million).	• The US federal government spends more than US $13 billion —14 percent of all federal R&D expenditures—to support work at 38 Federally Funded Research and Development Centres (FFRDCs). These centres are often (not always) co-located on or adjacent to US university campuses. . • Sponsoring agencies contract with nonprofit, university-affiliated, or private industry organizations to operate the FFRDCs. Increasing the effectiveness of the management structures for the FFRDCs, including with respect to encouraging U-B research collaboration, has been a subject of continuing attention by the US federal government.	• UK has "Large Facilities Roadmap" in place for funding and location of "big science" infrastructure. But the roadmap has been criticized for failing to take sufficient account of creating linkages with "external partners." • Major UK government research assets were privatized during the 1990s, reducing co-location as a policy instrument to encourage U-B research collaboration.	• Commonwealth Scientific and Industrial Research Organization facilities often co-located with (or adjacent to) universities. • Spatial distribution of R&D activity (already focused in a few major centres) reduces opportunities to further encourage U-B research collaboration through co-location of public research assets with those of universities and business.

Exhibit II (continued)

GOVERNMENT AS ENABLER (continued)	Canada	US	UK	Australia
Other Enabling Measures	• Various small scale programs in place to facilitate university researcher / employee mobility between the university and business sectors (e.g., the Natural Sciences and Engineering Council's *Collaborative Research and Training Experience* program). • Linkages between Canada's sector skills councils and universities remain weak. The councils receive substantial federal funding and focus on the college sector. • There are a variety of different organizations with varying memberships (and degrees of government support) that act to strengthen professional skills for knowledge transfer, but no single national organization	• Funding for the US National Science Foundation's *Advanced Technology Program* has been increased (the program is in part targeted at encouraging collaboration in skills development between businesses and 2 year colleges but the program is now expanding connections between employer groups and other higher education institutions).	• The UK Government's *Knowledge Transfer Partnerships* program seeks to strengthen the two way flow of knowledge and skills between the two sectors through negotiated partnership agreements between universities and companies. Almost 1,000 businesses and over 100 UK universities are involved in the program. The UK government invested £42 million in the program in 2009/2010 alone. • UK government provided launch funding for the UK Institute of Knowledge Transfer which seeks to improve the skills of knowledge transfer professionals in university and industry. • Employer-led skills councils remain largely focused on vocational education sector.	• Various programs in place (e.g. *Researchers in Business Program*). • Employer-led skills councils are largely focused on vocational sector, but efforts are being made to strengthen their linkages with the university sector.

Exhibit II (continued)

GOVERNMENT AS FUNDER	Canada	US	UK	Australia
Research Grant Processes and Conditions	• The federal government spends more than C$ 370 million annually on programs to encourage U-B collaboration and through multiple bodies (e.g., the research granting councils; the National Research Council of Canada; and regional development agencies). The two main federal funding programs to encourage U-B research collaboration are the *Business-Led Networks of Centres of Excellence* program; and the *Centres for Commercialization & Research* program. • There are many provincial government funding programs designed to encourage U-B research collaboration. Ontario uses a third-party organization (OCE Inc.) to deliver its programs.	• Scale of federal funding of R&D for defence, health and energy dwarfs those of other countries and much of this spending premised on U-B collaboration. Defense and Energy Advanced Research Project Agencies, and the *Small Business Innovation Research Program*, are the most prominent federal R&D spending programs and all three are premised on encouraging U-B research collaboration. • National Science Foundation grant review process includes U-B collaboration as one criterion for funding. US state funding of university research is significant and often structured to encourage U-B collaboration.	• The UK has provided over £ 1 billion over the past decade to universities for "knowledge-based interactions between the higher education sector and organisations in the private, public and voluntary sectors, and wider society." An estimated 50% of this amount goes to support university knowledge exchange staff. • The UK Technology Strategy Board is the main business R&D funding institution. It also seeks to use this funding to create an effective "ecosystem" for U-B research collaboration (the TSB is now overseeing the £ 200 million investment (over five years) in the government's new Technology and Innovation Centres (TIC)	• In 2009 federal government revised the Institutional Grants Scheme (IGS) for universities to encourage U-B collaboration. • There are multiple research granting programs often premised on U-B collaboration. The federal government funds a system of 48 Co-operative Research Centres involving businesses, industry associations, universities and government research agencies. • In 2010 the federal government created the *Commercialisation Australia* organization to deliver all its major research commercialization programs (funded to a level of A$ 244 million over the five years (FY 2010 – 2014).

Exhibit II (continued)

GOVERNMENT AS FUNDER (continued)	Canada	US	UK	Australia
Cluster Policies	• At the federal level, delivered through NRC and federal regional development agencies. Lack of clarity on impact of funding.	• At the federal level, delivered through US Economic Development Administration. Lack of clarity on impact of funding.	• Will in future be delivered through a new system of Local Development Enterprises. Lack of clarity on impact of funding.	• At the federal level, delivered through various funding mechanisms and institutions. Lack of clarity on impact of funding.
Other Fiscal Incentives	• Formal objectives of the federal R&D tax credit do not include encouraging U-B research collaboration (although business expenditures on university research are taken into account in the credit's design and administration). Ontario and Québec have specific R&D tax credit programs to encourage U-B collaboration. • Provinces experimenting with voucher programs (which subsidize SMEs in purchase of commercialization services from universities and other providers).	• One element of federal R&D tax credit (basic research credit) designed to encourage U-B research collaboration, as are some state government R&D tax credits. • Federal government defense procurement is massive and "Triple Helix" (government-business-higher education collaboration) is a dominant feature. U-B policy lessons for others unclear given their different circumstances in scale and purposes of funding.	• UK considering expanding tax based incentives to prevent "offshoring of IP" (broader than just university created or owned IP). • Small scale voucher programs encourage SME interaction with universities through subsidizing their purchase of commercialization services from universities. • UK government supporting universities & businesses to access offshore procurement opportunities.	• New R&D tax credit system proposed in 2010 (its design will allow university-owned start-ups to be eligible for the credit). • Australian State Governments experimenting with voucher programs for SMEs. State of Queensland voucher program funds university capacity to implement voucher program.

Exhibit II (continued)

GOVERNMENT AS RULE-MAKERS	Canada	US	UK	Australia
Intellectual Property (IP)	• Federal granting councils are seeking to provide universities with greater "flexibility" in managing IP associated with federally funded research. Some observers view diversity of policies and management practices across Canadian universities an obstacle to U-B research collaboration. • Provincial governments recognize IP policies and management can be strengthened within universities. (e.g., Ontario has stated (2009) that it will encourage adoption of best practices in IP policy and management and "…encourage the development of IP models and approaches that will maximize the benefits of research programs to Ontario."	• Continuing debate over future of the *Bayh-Dole Act* (and merits of inventor vs. university ownership model for IP generated through federally funded research). • National Academies study (2010) focusses on improvements to IP management processes in university settings and sets out a supporting role for the US federal government.	• Issue of IP practices as barrier to U-B collaboration first highlighted in Lambert Report (2003). • UK Intellectual Property Office has worked with business and universities to introduce of common and standardized IP management processes (e.g., Lambert Model Agreements). • The UK Government has launched (2010) an independent review is underway on how the UK IP system can better drive growth and innovation.	• Legal challenge (2009) to current "university ownership" model in Australia may spark federal government action. • 2009 *Powering Ideas* innovation agenda identifies management of IP processes in university settings as a challenge area.

Exhibit II (continued)

GOVERNMENT AS RULE-MAKERS (continued)	Canada	US	UK	Australia
Other Areas of Rule-making (continued)	• Good track record on regulation of research from U-B collaboration perspective. Various studies commissioned by the federal government to improve research integrity and ethics. • Foreign investor undertakings (under the *Investment Canada Act*) are currently not made public May be a missed opportunity to broaden public understanding of the benefits of foreign investment.	• Federal government regulation/funding of stem cell research remains politically contentious. US state governments have not waited on federal policy development in this area. • US Food and Drug Administration's *Critical Path Initiative* focused in part on encouraging U-B collaboration in human therapeutic products; • Export control reform underway and may help remove some export control-related barriers to U-B collaboration.	• UK policy experience not addressed in this report – remains a subject for future research.	• Federal government reviewing regulatory environment for the conduct of clinical trails – outcome may have implications for U-B research collaboration environment for development of new human therapeutic products.
University Governance	• Largely within the jurisdiction of provinces. Has not been major public policy issue to date.	• Not a major public policy issue to date.	• UK governments supported establishment of a "University Leadership Foundation" and a "Code of Best Practices".	• Federal government introducing "mission-based" compacts with universities to help advance its 2009 *Powering Ideas* policy agenda, including U-B research collaboration.

Government Policies to Encourage University-Business Research Collaboration in Canada: Lessons from the US, the UK and Australia

DETAILED SUMMARY

This report reviews findings from the research literature on motivations for, barriers to, and determinants of university-business (U-B) research collaboration. It examines how U-B research collaboration is measured and Canada's international ranking. It describes public policy measures for encouraging U-B research collaboration in Canada and three reference countries – the US, the UK and Australia. Drawing on the results of this work, the report provides recommendations on how Canadian governments can strengthen their role and effectiveness as advocates, enablers, funders and rule-makers for U-B research collaboration.

Motivations and Barriers to U-B Collaboration

Universities and businesses have different motivations for collaborating. In general, surveys of businesses in Canada, the US, the UK and Australia find that businesses collaborate with universities to access talent and facilities found at universities. They do not rank increasing their profitability as their top motivation for collaborating with universities. Businesses often report that the "long-term orientation" of university research is a barrier to collaboration. However when firms engage with universities on research projects with longer time-frames (although not indefinite time frames) this may serve to help focus them on real productivity enhancing product, process, and service innovations that meet customer needs.

Determinants of U-B collaboration

Business determinants for entering into research collaborations with universities have been the subject of extensive academic study. The main findings are:

- **large firms are more likely to collaborate with universities than are small firms.** However, there is good reason for policy makers to focus on encouraging collaboration between smaller firms and universities. Firm size has generally not been found to be a robust predictor for innovation. In fact, while large firms do spend more on R&D than smaller firms, due to their size and greater profits, they may not be intrinsically more innovative. Indeed, small firms are found be more innovative per dollar of R&D;

- **U-B collaboration is more likely to occur in some economic sectors than others.** The extent of U-B collaboration within any jurisdiction reflects the research intensity of different economic sectors. Cross-national differences in U-B collaboration may reflect differences in the structure of national economies.

The policy implication is that rather than seeking to encourage U-B research collaboration across all economic sectors, governments should target and focus their support where there is business interest and market opportunity. However, this should not come at the expense of supporting basic and fundamental research in the higher education sector;

- **firms tend to collaborate with universities that are nearest to them.** The policy implication is that sub-central governments (e.g., provincial and municipal governments in Canada) have as great a role to play in encouraging U-B collaboration as do national governments;

- **multinational companies take the presence of, and access to, high quality universities into full account when allocating their global R&D investments.** The policy implication is that encouraging foreign investment by research intensive multinational companies requires continued public investment in internationally competitive and research intensive universities; and,

- **in the specific case of tax-based incentives for business R&D, little is known about their impact on the level of business funding of university research.** However, tailoring R&D tax credits to encourage U-B research collaboration involves some risk that it will incent firms to substitute spending on internal R&D for external R&D rather than increasing their total investment in R&D and allocating it between internal and external performers according to what makes the most business sense.

Measuring Canada's International Ranking on U-B Research Collaboration

This report finds that Canada is not significantly lagging other comparator countries in U-B research collaboration. But neither is Canada a world leader in U-B research collaboration.

- According to World Economy Forum's annual survey of business opinion, Canada has climbed in the rankings of countries with extensive U-B research collaboration from 15th place in 2007 to 7th place in 2010 (even as the number of countries included in the survey rose from 131 to 139 over the same period and even though Canada ranked in 6th place in 2001). An annual survey of business opinion in 58 countries and conducted by the Institute for Management Development (IMD) places Canada in 8th position in 2010. (Indicators 1 through 3 in Exhibit I of the Executive Summary).

- When measured as a share of GDP, business investment in university research is: 0.06 percent of GDP in Canada; 0.02 percent in the US and the UK, and 0.03 percent in Australia. Canada also leads all but four other OECD countries according to available data on the percentage of higher education expenditures on R&D (HERD) that is financed by business. The OECD reports that Canadian businesses financed 8.5 percent of HERD in 2008 compared to 5.7 percent in the

US; 4.6 percent in the UK; and 4.9 percent in Australia. (Exhibit I, indicators 4 through 6).

- The number of university-industry co-authored (UIC) science and technology publications is increasing internationally, in part driven by increasing UIC publication rates in China. According to one group of researchers, Canadian UIC publications increased almost continuously between 1980 and 2005, rising from a 15 percent share of total industry written papers in 1980 to a 55 percent share in 2005. Canadian UIC S&T publications have reached and possibly exceeded the rates achieved in the US over recent years. (Indicator 7 in Exhibit I of the Executive Summary).

- Internationally comparable indicators of technology transfer and commercialization are challenging to construct and are subject to wide interpretation. Based on 2004 data assembled by two experts, the US leads the UK and other EU countries by indicators of commercial potential (e.g., patent applications and patent grants per dollar of research expenditure), while universities within the UK and other EU countries lead by indicators of commercial application (e.g. licenses executed and university start-up companies formed per dollar of research expenditure). US universities lead all jurisdictions by license revenues received as a percentage of total university research expenditures. Canadian and Australian universities present a mixed picture relative to other jurisdictions. (Indicators 8 through 15 in Exhibit I of the Executive Summary).

- Although also of limited international comparability (and full results from the first national innovation survey in the US conducted in 2009 are not yet available) the results from available national innovation surveys provide no evidence to assert that Canada is lagging major comparator countries in U-B research collaboration. (Indicators 15 and 16 in Exhibit I of the Executive Summary).

Summary Observations on the Public Policy Experience in Encouraging U-B Research Collaboration in the US, the UK and Australia

The United States

- US state and local governments are more vocal advocates for U-B research collaboration than is the US federal government. However, the US federal government is increasing its advocacy role through, for example, establishing the National Advisory Council on Innovation and Entrepreneurship and undertaking public consultations on how to improve the commercialization of federally funded research.

- The US federal government relies on intermediary organizations as conduits for, and managers of, considerable federal funding for research that is conducted at universities and sometimes co-funded with business. In a number of cases the US federal government has contributed to start-up funding for these organizations. Two examples provided in this report are the Semiconductor Research Corporation and the Critical Path Institute for drug development and research. The US federal government has also provided legislative room (e.g., permissive competition/anti-trust regulation) for establishing intermediary organizations involving industry consortiums.

- There are a number of longstanding US federal funding programs directly targeted at encouraging U-B collaboration, including the US National Science Foundation's University/Industry Cooperative Research Centres program and its National Engineering Research Centres program. Both of these programs are evolving to embrace a broader range of universities, disciplines, and industry sectors. However, a broader perspective on the US federal government as funder of U-B research collaboration takes account of the sheer quantity of financial resources spent for defence, health and, more recently, energy research, and through a vast labyrinth of funding programs (including the Small Business Innovation Research program).

- Many observers have delivered an academy award to the US for the *Bayh-Dole Act* of 1980 which created a presumption that title to federally funded inventions will vest in the contractor, including a university, rather than in the government or an individual inventor. But a vigorous debate has emerged on whether an inventor or a university ownership model should continue to prevail under Bayh-Dole (there is now a case involving the same subject before the US Supreme Court). The US is also devoting attention to improving IP management processes and structures within universities and the potential role of the US federal government in this effort.

- There are cases where uncertainty over federal regulation of research (e.g. stem-cells) has adversely impacted U-B collaborative research. Another area of government regulation of research involves national security. National security concerns permeate all areas of public policy in the US and the policy area of U-B collaboration is not immune. For instance, export control systems have complicated U-B research collaborations in the US and the US federal government is struggling to find the right balance between national security and a liberal environment for the conduct of U-B collaborative research.

The United Kingdom

- No other OECD national government has been as loud an advocate for U-B research collaboration as has been the UK government. The *Lambert Review of Business-University Collaboration*, commissioned by the UK Treasury and published in 2003, provided UK businesses, universities and governments with a clear roadmap for strengthening U-B collaboration. However, during 2010 there emerged in the UK a growing sense that "more can be done." From this perspective, the UK Government's November 2010 *Technology Blueprint* may be seen as a new roadmap for U-B collaboration in the UK – one that ties U-B research collaboration more closely than ever before with UK innovation policy goals;

- For over a decade the UK government has been a major funder of U-B collaboration through "third stream funding" to universities for "knowledge exchange" with external organizations, including UK businesses. Between 2000-01 and 2010-11 this funding amounted to £ 1 billion (at 2003 prices). Over the next five years almost one-half of this support will go to fund knowledge exchange staff at universities;

- The UK government is funding a new generation of intermediary organizations to encourage U-B research collaboration to be known as Technology and Innovation Centres. The UK government will invest over £ 200 million in centres over the next four years and through UK Technology Strategy Board (TSB). The TSB is an arms-length (from government) organization responsible for an increasingly large proportion for UK government funding for research, development and deployment (and in close cooperation with the UK Research Councils).

- Large investments of time and financial resources have been made by UK government bodies to support the development of model IP agreements to be used by universities and business. UK governments are also using fiscal incentives to capture benefits from the commercialization of IP (whether originating or owned by universities or others).

Australia

- Australian governments have been increasingly strong advocates for greater U-B collaboration since the 1980s. They have instituted formal and annual reporting systems on U-B collaboration and, in publishing the results, are including international benchmarks. The Australian federal government has made strengthening U-B collaboration one of its top five priorities within its 2009 national innovation strategy, *Powering Ideas*.

- Australian governments are employing a range of research funding institutions and instruments to encourage U-B collaboration. Beyond conditions attached to research grants, the Australian federal government has: invested A$ 250.7 million (over five years starting in 2008) in a new tranche of intermediary organizations (six manufacturing centres and six innovation centres); introduced a Joint Research Engagement Program (which de-links block grants for university research from a university's success in obtaining competitive research funding from public sources); and created a new organization, Commercialisation Australia, to deliver major government programs for the commercialization of research (funded at a level of A$ 244 million over the five years FY 2010 - 2014, with ongoing funding of A$ 82 million a year thereafter).

- The Australian federal government is an active rule-maker for improving the environment for U-B collaboration. Its 2009 *Powering Ideas* innovation agenda highlights that greater clarity and certainty in the management of intellectual property in university settings should be given attention (a recent Australian court decision involving the issue of university/inventor ownership of IP may prompt further government attention to university IP policies and processes).

- The Australian federal government is now negotiating three-year agreements with universities that will show how each university's mission contributes to the Government's goals for higher education. The model agreement, issued by the federal government in October 2010, asks universities to make comments or commitments on their plans and priorities for contributing to innovation and economic growth, including how they propose to use Commonwealth funding to: collaborate or partner with industry; contribute to knowledge transfer; or improve commercialization outcomes.

The university and business sectors in the US, the UK and Australia have established on their own initiative forums that bring their leaders together to advance their respective interests. In particular:

- the US Business Higher Education Forum is comprised of Fortune 500 CEOs, university presidents and foundation representatives. The US Council of Competitiveness, with a broader mandate than just university-higher education relationships, includes CEOs and university presidents but also includes labour leaders. US governments do not directly fund these forums, but they do listen to them;

- the Council for Industry and Higher Education (CIHE) was established in 1986 by UK business and university leaders and is modeled on the US Business Higher Education Forum. It receives no significant funding from the UK Government. In addition, the UK's main business organization, the Confederation of British Industry (CBI) has created within its own organization an Inter-Company Academic Relations Group (ICARG) that "brings together a wide range of business, government and other organisations in order to exchange ideas, network and provide a forum for regular dialogue";

- the Australian federal government created and funded a Business Industry Higher Education Collaboration Council in 2005 but the council closed its doors in 2008 as the end of government funding came into sight. In contrast, an organization created in 1990 by Australian business and university leaders to strengthen the relationship between the two sectors (the Business-Higher Education Round Table (B-HERT)) continues to thrive. Its membership comprises Australian universities, corporations, professional associations, but also major public research organizations, including the Commonwealth Scientific and Industrial Research Organization (CSIRO); and

- In Canada, the Canadian Corporate-Higher Education Forum (C-HEF) was established in 1983 to bring the leadership of major Canadian businesses into contact with university leadership. C-HEF began to fade-away by 2000, possibly because of generational change in university and business leadership or perhaps because it failed to deliver value to its members. In any case, today Canada has no permanent, national, and "peak-level" association or forum that brings together university and business leaders to strengthen the relationship between the two sectors.

What lessons should Canadian governments draw from the experience of others and their own policy experience in order to strengthen their own role and effectiveness as advocates, enablers, funders and rule-makers for U-B research collaboration?

Canadian Governments as Advocates for U-B Collaboration

Canadian governments have been strong advocates of U-B research collaboration since the early 1980s. They have positioned U-B collaboration as a prominent objective within their innovation policy strategies and statements, revised the mandates of some of their research funding institutions to include encouraging U-B collaboration, established various public recognition prizes and awards for U-B collaboration, and are starting to measure and report on U-B collaboration. For example:

- U-B collaboration is a policy priority within the federal government's Science and Technology strategy and in most provincial and territorial government innovation strategies. The federal government's Science, Technology and Innovation Council is starting to measure and report every two years on U-B collaboration. Encouraging "partnerships" is now embedded as an advocacy activity within all three federal research granting councils and the National Research Council of Canada;

- a number of provincial governments have made "machinery of government" changes that, from a U-B advocacy perspective, symbolize the importance they place on U-B collaboration as one component of their innovation strategies. Examples include: British Columbia's new Ministry of Science and Universities (2010); Alberta's creation of the Alberta Innovates – Technology Future organization (2009); Newfoundland and Labrador's new Research and Development Corporation (2009); Ontario's creation of the arms-length and not-for-profit OCE Inc.; and Québec's merging of its existing research financing organizations into a single organization known as the Fonds Recherche Québec (Québec Research Fund) in 2010; and,

- local governments who invest in or otherwise support university research parks and associated business incubator facilities have become strong advocates of U-B collaboration both as a part of their local economic development strategies and as city branding strategies.

There are at least three areas where Canadian governments can strengthen their role as advocates of U-B research collaboration.

- What governments decide to measure and report to citizens matters to the development of public policy and the exercise of national influence on the world stage. Government agencies in Australia, the UK and the US are increasing their effort to better understand and report on U-B collaboration. Canada has been a follower rather than a leader in this area.

- Senior levels of government in Canada should include municipal governments more deeply and more often in the design and implementation of measures to encourage U-B collaboration. Municipal governments are at the front line of local economic development activity and hold great but unrealized potential to be stronger partners in U-B advocacy by governments. In the US, it is state and local governments who are leading advocates for U-B collaboration. There are, however, Canadian models to be drawn upon, including the MaRS Discovery District in Toronto and the Alberta Centre for Advanced Microsystems and Nanotechnology Products (ACAMP) whose board of directors is chaired by the CEO of TEC Edmonton (a not-for-profit joint venture between the University of Alberta and the City of Edmonton's Economic Development Corporation).

- Informal interactions in Canada between business and universities are as likely important as formal interactions. Therefore, harnessing the interest and the influence of individual Canadian business and university leaders, and university faculty and researchers, will be critical to advocacy efforts for U-B research collaboration. But this report does <u>not</u> find that, as part of this effort, government should take the lead in helping establish a new organization or forum that brings university and business leaders together.

Main Recommendation

The federal government should issue a clear statement of its objectives and expectations for the future of U-B research collaboration in Canada that can both inspire and serve as a touchstone for measuring progress (the Government of Québec is already moving in this advocacy direction through setting out, within its 2010 innovation policy statement, its target for U-B research collaboration in Québec). However, the federal government should resist the temptation to take a leadership role in establishing or funding a new forum that brings together university and business leaders. Even though such forums exist today in the US, the UK and Australia, and have existed in Canada in the past, Canadian university and business leaders themselves must decide if such a forum is required and what useful functions it could serve.

Canadian Governments as Enablers of U-B Collaboration

Canadian governments are enablers of U-B collaboration through providing financial and other forms of support for the establishment and operation of a large number of intermediary organizations that sit between universities and businesses. Examples of such organizations include: the MaRS organization in Toronto; CMC Microsystems in Kingston; the Composites Innovation Centre in Winnipeg, the Centre for Drug Research and Development in Vancouver, Innovacorp (a Government of Nova Scotia Crown Corporation), and the PROMPT and CRIAQ organizations based in Québec. These organizations, and similar organizations found in the US, the UK, Australia, and many other developed economies, help:

- businesses search for, screen, and absorb knowledge and ideas from universities and access talent and research infrastructure at universities – activities that are often costly and time consuming for all businesses and may often be beyond the financial reach and other capacities of small and medium sized businesses;

- connect universities and individual academics with sources of business knowledge and markets and open up opportunities for them to test out their ideas and apply their knowledge;

- provide a negotiating forum and act as facilitator to reconcile the different motivations and interests of the two sectors through helping establish social trust, connectedness, and confidence between individuals and disparate groups from both sectors; and,

- are increasingly important conduits for governments to fund research, including U-B collaborative research.

This report finds that Canadian intermediary organizations are today characterized by:

- strong national and regional coverage (e.g., there are four regional networks for the commercialization of research, a national association, and many sub-regional commercialization networks);

- considerable sectoral coverage (both technologies and economic sectors) although further research is required to see what gaps remain;

- good representation from the university and business sectors on their boards of directors;

- are increasingly connected with one another rather than operating in isolation (e.g. MaRS is now linked with the Centre for Drug Research in British Columbia; PROMPT in Québec and CMC Microsystems have a partnership agreement; and ISTPCanada is connected to multiple other intermediary organizations as it forges international U-B partnerships and linkages); and,

- are not regarded by universities or the federal research granting councils as competitors for scare public resources. In Canada, the federal research councils increasingly use these organizations to flow some of their research funding to universities (e.g. the tri-council Business-Led Networks of Centres of Excellence program and the Centres of Excellence for Commercialization and Research program).

This report also finds that Canadian governments can be stronger enablers of U-B collaboration in the future through:

- encouraging intermediary organizations to intensify their efforts to look beyond regional and national boundaries in the exercise of their functions. As of yet, no Canadian intermediary organization can claim to have achieved the reach of the US Semiconductor Research Corporation, a US intermediary entity that has formal research funding connections with over 130 universities and technology institutes in the US and abroad; and,

- stepping back to take a system-wide perspective on the coverage (sectoral and technological), role and effectiveness of intermediary organizations.

Main Recommendation

The federal government should review the role and effectiveness of intermediary organizations the sit between universities and business and which are increasingly important conduits for federal funding of U-B research and related commercialization activities. The review should address at least three questions: (1) are there significant gaps in sectoral or technological coverage or in the type of intermediation activities and services offered?; (2) should longer-term financial support be provided to some of these organizations for some portion of their operational expenses?; and (3) are they sufficiently transparent and accountable conduits for helping to assemble and flow public research dollars to U-B research projects?

Canadian Governments as Funders of U-B Collaboration

This report estimates that the federal government is spending at least C$ 370 million annually on programs that have encouraging U-B collaboration as a major objective. The report also finds that Canadian governments are:

- attaching industry participation conditions (implicitly or explicitly) to research funding for universities, funding large scale S&T infrastructure and projects premised on U-B collaboration, and using defence procurement to incent U-B collaboration. Provincial governments are experimenting with new funding mechanisms to support U-B collaboration including, for example, the introduction of various forms of "voucher" programs (voucher programs, typically of low cost to taxpayers, subsidize the purchase of various "commercialization" services, including from the higher education sector, by small and medium sized enterprises);

- incorporating business perspectives in making some research grant awards to universities (e.g., the federal government has created a Private Sector Advisory Board with respect to awards made through three federal research council grant programs); and

- continuing to fund such globally renowned programs as the Industrial Research and Assistance Program (IRAP) run by the National Research Council of Canada. For over sixty years, IRAP has provided a range of technical and business-oriented advisory services, as well as financial support for smaller businesses to develop, adopt or adapt technology. Encouraging U-B research collaboration is not a stated objective or primary goal of IRAP, although in design and administration it does have that effect. In 2009, the Federal Budget allocated additional funds to the NRC to allow it to expand IRAP's support for small and medium-sized businesses.

There is no evidence to suggest that this funding is going to waste. But on the other hand, and as in other areas of government support for R&D, it is extraordinarily difficult to attribute outputs or outcomes (as measured by any given indicator or group of indicators) to any specific government policy measure or program. However, this should not stop government from strengthening existing funding measures and processes. For example:

- the Canadian federal government has placed an emphasis on seeking "private sector input" at the initial resource allocation stage for some research funding programs. Greater attention might now be paid to increasing private sector involvement during the actual research process itself;

- Canadian provincial governments are beginning to embrace an open and international vision for the future of Canadian voucher programs. In this program area, Canadian governments have the opportunity to position Canada as an international leader for global openness in knowledge creation and exchange. Today only three out of the 25 voucher schemes in the European Union have a limited degree of international reach and openness. By designing voucher programs that have regional, national and international reach and openness, Canadian governments can encourage smaller companies to look beyond local borders for knowledge and business opportunities. Making vouchers available to foreign companies could bring them (and foreign investors) to look more closely at opportunities to work with Canadian universities;

- for decades Canadian governments have been asked to "lever" public procurement to achieve an ever expanding number of social and economic objectives. In 2010 the federal government introduced a new defence procurement incentive to encourage the formation of university-business consortiums to conduct defence related research. This specific initiative follows in the path being taken by other governments around the world. Both civil and defence procurement programs in other countries are also incorporating requirements for suppliers to collaborate with institutions of higher education. Governments, businesses and universities in other countries have taken note of this development. Canadian governments should consider what useful support they can offer to Canadian universities and business to support their joint involvement in overseas procurement opportunities; and,

- there are an increasing number of programs and initiatives for encouraging the commercialization of research at federal and provincial levels of government and delivered through a long list of governmental organizations. The time may have come for at the least the federal government to consider institutional options for the more effective coordination and delivery of these programs. There are many different models to be drawn on. For instance, since 2004 the Government of Ontario has used an arms-length organization (OCE Inc.) to manage the delivery of its major funding programs to encourage U-B research collaboration and commercialization of the results. The UK's Technology Strategy Board (TSB) is another model of an organization at arms-length from government that delivers direct government support for business R&D and, at the same time, is mandated to encourage U-B research collaboration. The Australian federal government has created Commercialisation Australia to centralize the delivery of many of its research commercialization programs (it is not an "arms-length" organization but does exercise considerable independence in its decision-making process and is guided by a tripartite board (comprised on business, university and labour representatives).

Main Recommendation

The federal government should examine the option of moving lead responsibility for many existing funding programs for U-B research collaboration and related commercialization activities to a single organization operating at arms-length from government. Such an organization could pursue tangible and unambiguous objectives that are grounded on real market circumstances and opportunities. It does not have to be "business-led" but must have business and university participation and support.

- Canadian governments have long used the tax system to support business R&D through various tax deductions and tax credits for eligible research and development expenditures. Today the federal Scientific and Experimental Development Research and Development (SR&ED) tax credit is the main policy instrument employed to stimulate business investment in R&D. This report examines whether, strictly from the viewpoint of seeking to encourage U-B research collaboration, the federal government should enrich the SR&ED tax credit program to stimulate business investment in university research or continue to place reliance on direct program spending. This report finds that:

- the SR&ED tax credit has never been portrayed by the federal government as having encouraging U-B research collaboration as its primary objective. However, in both design and administration the federal SR&ED tax credit already takes into account that businesses allocate some of their research investments to university performers. However, little is known about the impact of the existing SR&ED tax credit on U-B research collaboration. The Canada Revenue Agency and the Department of Finance do not release to the public information on SR&ED tax credits earned or claimed for research expenditures incurred through third-party research and contract research.

- redesigning the SR&ED tax credit specifically to encourage U-B research collaboration carries some risk of decreasing the level of business investment in their internal R&D activities. One academic study in the US finds that, on average, the sample of firms considered shifted away from in-house R&D when faced with lower relative prices of external contract research (brought about by state-level R&D tax credit design). Relying on results from a single study is generally not a sound basis upon which to make a critical public policy decision. Nonetheless, the finding does underline that the law of unintended consequences may apply when seeking to use general R&D tax credits for specific purposes, in this case encouraging U-B research collaboration; and

- choosing between using the tax system and direct program spending to encourage U-B collaboration involves the same fundamental considerations as making the same policy instrument choice in other areas and for other purposes of public policy. Canadian economists Richard Lipsey and Kenneth Carlaw have suggested that tax incentives may be most effective as framework policies that provide general support for specific activities across the entire economy and that do not discriminate between firms, industries or technologies. Direct program spending may be most effective where market failures are large and concentrated in localized situations.

Main Recommendation

The federal government should continue to provide direct funding to encourage U-B research collaboration at least up to current levels (estimated in this report as being over C$ 370 million annually) rather than enriching the existing Scientific Research and Experiment Development (SR&ED) tax credit specifically to incent businesses to allocate a higher proportion of their R&D spending to university research.

Canadian Governments as Effective Rule-makers for U-B Collaboration

There are a number of areas of rule-making that influence the environment for U-B collaboration and in which Canadian governments generally have a good track record. But this report also finds:

- the federal government's Natural Sciences and Engineering Research Council revised its intellectual property (IP) policy in 2009 in part to provide universities with greater "flexibility" on how they treat IP generated from NSERC's research grant awards. Diversity and flexibility in university IP arrangements are seen by some as desirable, but others view them as impediments to U-B research collaboration. The US, the UK and Australia are all seeking to bring greater certainty and consistency in their IP processes within university settings and with varying degrees of success;

- the Canadian federal government should commission research on the potential benefits and costs of using the Canadian tax system to encourage the exploitation of IP generated in Canada (including through Canadian universities). The Government of Ontario has such tax provisions in place although its impact has not yet been subject to close scrutiny. Without prejudging the possible results of such research, tax policy measures to encourage the exploitation of IP in Canada should be judged against their contribution (or otherwise) to building an internationally open trade and investment system;

- increasing the transparency of the foreign investment review process is likely desirable for many public policy reasons. One reason is that greater transparency will help ensure that the benefits of an open foreign investment regime, including encouraging U-B collaboration, will receive a higher profile than is currently the case; and,

- Canadian governments should continue to strengthen existing systems for the regulation of research in the face of an uncertain scientific and technological future. How governments choose to regulate research in many areas, including nanotechnology and synthetic biology, may be expected to impact U-B collaboration. Government rule-making in this area should be characterized by foresight, rather than seeking to patch up problems after the technological horse has left the laboratory.

Main Recommendation

The federal government should lead a structured national discussion involving businesses, universities, and provincial governments on how to improve processes for the negotiation and management of intellectual property (IP) within university settings.

Government Policies to Encourage University-Business Research Collaboration in Canada: Lessons from the US, the UK and Australia[1]

1.0 Introduction

There are many reasons why governments are interested in encouraging university-business (U-B) research collaboration. They see it as one way to: extract greater economic and social value from large and continuing public investments in education and research; bring the results of university based research more quickly to the marketplace and their citizens than might otherwise be the case; and open up new opportunities for universities to equip students with the skills and knowledge required to live and work in the twenty-first century. They believe it to be one means, although perhaps indirect, to strengthen the productivity of their business and social sectors and, through that channel, generate higher living standards for all.

Governments are also encouraging U-B collaboration to strengthen the position of their countries and businesses in the international economy. Within that economy, a number of traditional bases for international competitive advantage, including labour costs and tax regimes, remain important but are of diminishing value. One exception is knowledge (another exception is natural resource endowments). Knowledge has always been an important source of competitive advantage but its relative value is increasing. Of course, this observation is not new. In 1997 the UK's National Committee of Inquiry into Higher Education (Dearing) said:

> "In a global economy, the manufacturers of goods and providers of services can locate or relocate their operations wherever in the world gives them greatest

[1] The author is a senior research associate at the Centre for the Study of Living Standards (CSLS). The author thanks the Government of Canada's Department of Industry for funding an exploratory study on U-B collaboration and its encouragement (through Shane Williamson and Karen Corkery at Industry Canada) for exploring the subject more deeply. The author also acknowledges and thanks the many individuals and organizations in Canada and abroad who shared their knowledge and insights, including: Rick Van Loon, Andrew Sharpe, and Ricardo Avillez at the CSLS; Louise Forgues at the University of Ottawa's Centre on Public Policy and Management; Herb O'Heron at the Association of Universities and Colleges of Canada; Jai Persaud and his colleagues at Canada's Science, Technology and Innovation Council; Michael Bloom at the Conference Board of Canada; Cindy Carter and Daood Hamdani at Statistics Canada; Jeffrey Kinder and Joy Senack at Natural Resources Canada; Stéphanie Michaud and her colleagues at NSERC; James Hull, Associate Professor of History at the University of British Columbia; Linda Quattrin of the MaRS Discovery District in Toronto; Dan McGillivray of OCE (Ontario Centres of Excellence) Inc., Larry W. Sumney, President and Chief Executive Officer, US Semiconductor Research Corporation; and Ihsan Karatayli, Senior Consultant, Technopolis Group in Turkey. Many others have provided invaluable information and insight. The author is also grateful for the views shared by public and private sector participants at the October 2010 CSLS seminar on U-B Collaboration held in Ottawa, Canada. E-mail: iancurrie@sympatico.ca

> competitive advantage. Competitive pressures are reinforced by the swift pace of innovation and the immediate availability of information through communications technology. When capital, manufacturing processes and service bases can be transferred internationally, the only stable source of competitive advantage (other than natural resources) is a nation's people. Education and training must enable people in an advanced society to compete with the best in the world." (HMG, 1997: C1 - 1.1).

More recently, Stanley Metcalfe, Professor Emeritus at the University of Manchester, has thoughtfully expounded upon the notion that countries should not only build knowledge advantages but differentiate them:

> "It is commonplace to say that the modern economy is knowledge based but a moment's reflection points to the vacuity of this notion. For all economies are knowledge based and could not be otherwise. The question is rather how is one kind of knowledge based economy to be distinguished from another?"(Metcalfe: 2010: 5)

Governments are asking themselves the same question.[2] Encouraging U-B collaboration is not the only or even the most important way for governments to differentiate and distinguish their knowledge economies from those of others. But it is an important reason for why encouraging U-B collaboration has attracted their attention and a considerable quantity of their political, financial, and other resources.

The report is presented in seven sections. The first section considers how U-B collaboration may be defined. It reviews findings from the research literature on motivations for, barriers to, and determinants of U-B collaboration. It considers how U-B collaboration is measured in Canada and other jurisdictions. The second section sets out a descriptive framework for organizing information on policy measures to encourage U-B collaboration. The third section examines Canadian public policies for encouraging U-B collaboration in the past and through to today. This is followed by three sections that review the policy development histories and current policies for encouraging U-B collaboration in each of three countries: the US, the UK and Australia. These three countries are treated as the reference countries because they share with Canada a common western university heritage as well as a common economic system.[3] The concluding section discusses potential lessons for Canada.

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[2] The same question was popularized through Thomas Freidman's *The World is Flat* (2005) and Richard Florida's *The World is Spiky* (2005).

[3] Of course, future research could include a larger group of countries that also share this heritage. In 2009 a US/UK study group of scholars reported to then UK Prime Minister Gordon Brown that: "The excellence of the UK and US systems of HE [Higher Education] rests in large part on shared values, particularly those linked to strongly-held notions of academic freedom. …Today, four HE systems – the UK (and Commonwealth – Australia, New Zealand, Canada), US, French, and German – treat it as a bedrock principle of the academy." (UK/US Study Group, 2009: 7). Future research should also pay attention to developments in other national jurisdictions. Richard

2.0 University-Business Collaboration: Definition, Motivations, Determinants, and Measurement

2.1 Definition

Many different classification systems have been advanced to describe the types of interactions between universities and businesses in research and other areas. Perkmann and Walsh (2007) point out that such classification schemes should not overshadow the relational aspect of university-business links, the importance of informal as well as formal interactions, and the two-way flow of knowledge between the two sectors.

In this report U-B collaboration is defined as the relationships established between the two sectors to advance their different interests and objectives. Research relationships are the main focus of attention because they have attracted the greatest attention of governments. U-B collaboration in research and other areas often take on the characteristics of a negotiation to achieve self-interested ends, although there is often a public interest at stake. The public interest varies according to the specific context at hand but, in general, it often reflects the core function of universities as producers of public goods: education certainly, but also the creation of knowledge through research.[4]

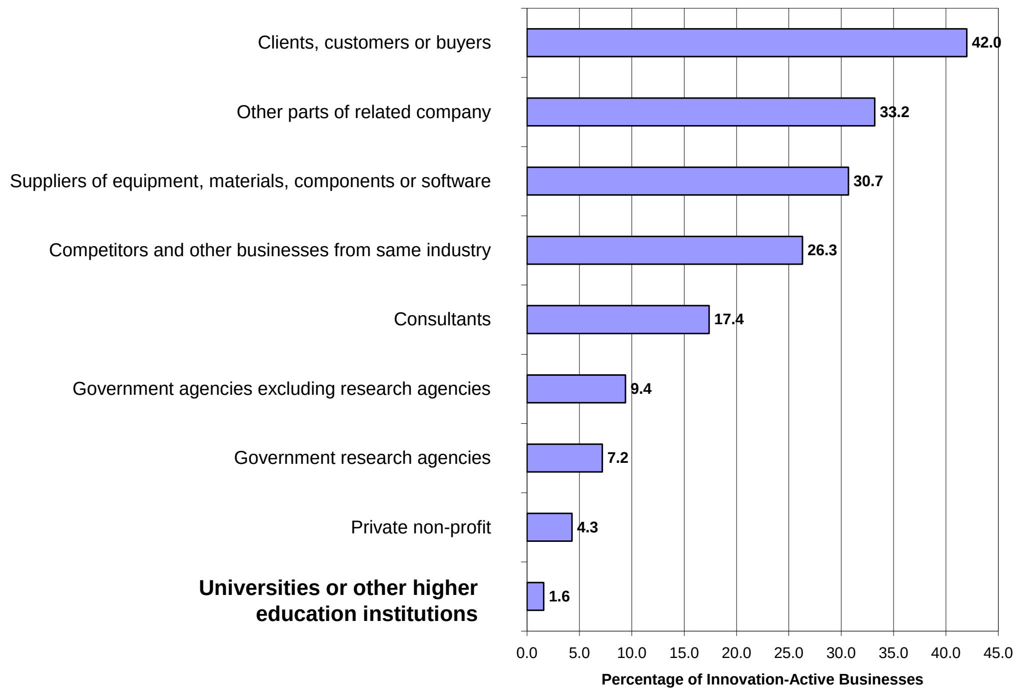
2.2 Motivations for U-B Collaboration

Cosh et. al. (2006) find that U-B research collaborations in the US and the UK are a quantitatively small part of the overall pattern of knowledge flows for innovation. Based on survey data, this is also the case across other OECD jurisdictions. Firms collaborate more with suppliers and customers on R&D than with other organizations, including universities. Statistics Canada's 2007 survey of Canadian manufacturing establishments found that 81 percent collaborated in innovation with suppliers, 78 percent with customers, and 31 percent with universities. Figure 1 (next page) presents the relevant national innovation survey findings from Australia. These survey findings do not devalue U-B collaboration. They do suggest that the quality and purpose of U-B collaboration matters more than the absolute number of U-B collaborations. They draw attention to the importance of understanding motivations for U-B collaboration.

Levin, President of Yale University, has pointed out that countries with different economic and social structures, particularly China, have rapidly changing and expanding higher-education systems (Levin, 2010).

[4] Knowledge is generally regarded by economists as a public good (although with some caveats) because it is difficult to exclude individuals from consuming knowledge and the consumption of knowledge by an individual does not reduce its availability for consumption by others. Stiglitz (1999) suggests that governments have adopted two strategies to increase the supply of knowledge as a public good: increasing the degree of appropriability of the returns to knowledge by issuing patents and copyright protection; and direct government support, including for basic research. From this report's perspective, the role for government in encouraging U-B collaboration often involves the development of public policies in both these areas.

Figure 1
Innovation-active Businesses Collaborating in Australia 2006-07
Percentage of all innovation-active firms



Source: Australia Department of Innovation, Science and Research (2010).

Note: The Australian survey data is not directly comparable with innovation survey data available from other jurisdictions due to differences in: survey coverage (e.g., all businesses in Australia but only manufacturing sector establishments in Canada); survey reference periods (e.g., 2006-2007 in Australia and 2002-2004 in Canada); and the survey questions themselves.

Business Motivations

Survey results from the UK and Canada on what motivates businesses to collaborate with universities in research and other areas are summarized on the next page: in Table 1 for the UK and Table 2 for Canada. The 2008 UK survey refers to motivations by “external organizations”, although 72 percent of the 367 survey respondents were from the private sector (with the remaining respondents being from the public sector and the charitable and voluntary sector). The 2010 Canadian survey, commissioned by The Board of Trade of Metropolitan Montréal, covers 204 companies in the province of Québec with 10 or more employees and greater than C$ 5 million in annual revenues. The Québec survey provides separate results for companies that have collaborated with universities in Québec over the past three years and those that have not.

Table 1
Motivations for Engaging with UK Higher Education Institutions (% of respondents reporting motivation as being of High or Medium Importance)

Rank	Motivation	Percentage of Respondents	Rank	Motivation	Percentage of Respondents
1	Obtain access to HEI facilities	45%	8	Improve product quality/reliability	19%
2	Enhance workforce skills training	35%	9	Increase number of clients/beneficiaries	18%
3	Enhance technology capability	28%	10	Enhanced branding of the organization	16%
4	Develop new products/diversify activity	26%	11	Improve marketing/market information	16%
5	Part of graduate recruitment strategy	23%	12	Improve profitability	15%
6	Enhance technology capacity	22%	13	Improve sales	15%
7	Enhance management skills/knowledge	22%	14	Improve customer service	14%

Source: "Evaluation of the effectiveness and role of HEFCE/OSI third stream funding." Report to the Higher Education Funding Council for England from Public and Corporate Economic Consultants (PACEC) and the Centre for Business Research, University of Cambridge (HMG, 2009a: 201).

Notes: The survey asks: "Which of the following have been the motivations and objectives of your organisation when interacting with the particular HEI?"

Table 2
Business Motivations for Collaborating with Universities, August 2010, Québec.

Motivation	Companies that have collaborated with a university in the last three years (n=104):	Companies that have not collaborated with a university in the last three years (n=90):
Access to qualified workers / top-notch talent	74%	47%
Contribution to the company's development and growth	52%	38%
Access to advanced expertise	45%	37%
Access to tax credits offered by the Quebec and Canadian governments / tax incentives	36%	23%
Raise the company's profile	30%	11%
Access to a stimulating research environment	19%	10%
Access to cutting-edge equipment	8%	4%
Other	3%	4%
Don't know / Not sure	5%	27%

Source: The Board of Trade of Metropolitan Montréal and Léger Marketing, 2010.

Note: The survey asks: "What motivates you or would motivate you the most to collaborate with a university?"

These UK and Canadian survey results are broadly consistent with other surveys of business in other national jurisdictions.[5] Businesses place access to highly qualified people, the development of their future labour force through the education of students, and access to university researchers and facilities, at or near the top of their motivations for collaboration. Perhaps obviously, businesses look to universities for access to knowledge and talent to strengthen their competitiveness.

Businesses generally do not list increasing their profitability as their top motivation for collaborating with universities in the UK survey or comparable surveys carried out in other jurisdictions. For instance, a 2010 survey of 300 businesses in Australia sponsored by the Australian Industry Group (Ai Group) found that generating immediate "commercial returns" is a less important motivator for businesses to collaborate with universities than other factors. [6] But the Ai Group's National Innovation Review Steering Group interprets this finding as an indication that U-B collaboration is falling short of meeting "commercial business expectations":

> "The Innovation Survey results reveal that 29% of firms have been involved in collaborative projects with external research providers such as universities and CSIRO. This number is higher than reported by the Department of Innovation, Industry, Science and Research which again suggests that self selecting respondents to this survey are more likely to collaborate. Those participating cite the solution of technical problems and the creation of future options for new products or services as the key outcomes. Importantly, collaborative projects were viewed as less successful from the perspective of generating commercial returns and achieving cost savings. In other words, there is a low level of active collaboration in Australia at present, and those business-research collaborations that are being pursued are, on the whole, falling short of meeting commercial business expectations. (Australian Industry Group, 2010: 12).

This raises a question discussed in greater detail in a moment: if increasing profitability (at least in the short run) is not a strong motivator for businesses to collaborate with universities, then why do other surveys suggest that businesses perceive the "long term orientation of university research" as a significant barrier to collaboration?

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[5] One limitation of surveys on motivations is that any number of finer and finer graduations of motivations may be inquired into and which solicit ever greater differentiation in responses. In effect, the more we ask the less we may know. Another limitation is the questions not asked in any given survey. In the two surveys of business cited here, the Canadian survey asks about "Access to tax credits offered by the Québec and Canadian governments / tax incentives" as a possible motivation but the UK survey does not ask about access to government support programs.

[6] The Australian Industry Group is an Australian industry association created through the merger in 1998 of the Australian Metals Trades Association and the Australian Chamber of Manufacturers. The Ai Group's National Innovation Steering Review Steering Group 2010 report on the survey results, *New Thinking, New Directions*, was developed by representatives from the Ai Group, but also by representatives from the University of Queensland's School of Business and the State Government of Queensland.

Academics

The motivations of individual academics to collaborate with business have been examined through surveys and empirical research studies. In 2008-2009, the Cambridge Centre for Business Research (CBR) carried out a survey of UK academics active in research or teaching.[7] The academics were asked to score a range of motives on a scale from 1 to 5 (where 5 is very important and 1 is unimportant). The highest ranked motivations for collaborating with "external organizations" (including business) were:

- gaining insights in the area of the academic's research (4.0);
- keeping up to date with research in external organisations (3.6); and
- testing the practical application of research (3.5).

The CBR survey found that the motivations that had the lowest rank were concerned with financial or commercial gain such as: personal income (2.2) and business opportunities (2.3). (Abreu et. al., 2009: 35)

D'Este and Perkmann (2010), in a regression analysis of results from a 2004 survey of UK academics in the physical and engineering sciences, also find that most academics engage with industry to further their research rather than to commercialize their knowledge. But other research, based on survey data from other jurisdictions, suggests that reputational and monetary benefits may not be inconsequential for longer term cooperation with firms (Audretsch, Bönte and Krabel, 2010).

Universities

The institutional motivations of universities to collaborate with business are even more diffuse and less easy to quantify than those of individual academics. There are a small number of surveys and studies (e.g., HMG, 2009a) that explore the relationship between university engagement with business and such long term and broadly defined institutional goals as: diversifying funding sources; expanding knowledge exchange activity; contributing to social and economic development; developing world class capabilities and reputation; and embedding knowledge exchange as a core activity.

A more extensive stream of research explores the characteristics of what has come to be called the "entrepreneurial university" (see Gibb, Haskins, and Robertson, 2009, for a literature review). But, as pointed out by D'Este and Perkmann (2010), this research often turns to examine the "micro-foundations" of such universities (i.e., the motivations of individual academics). As entrepreneurial universities are portrayed to

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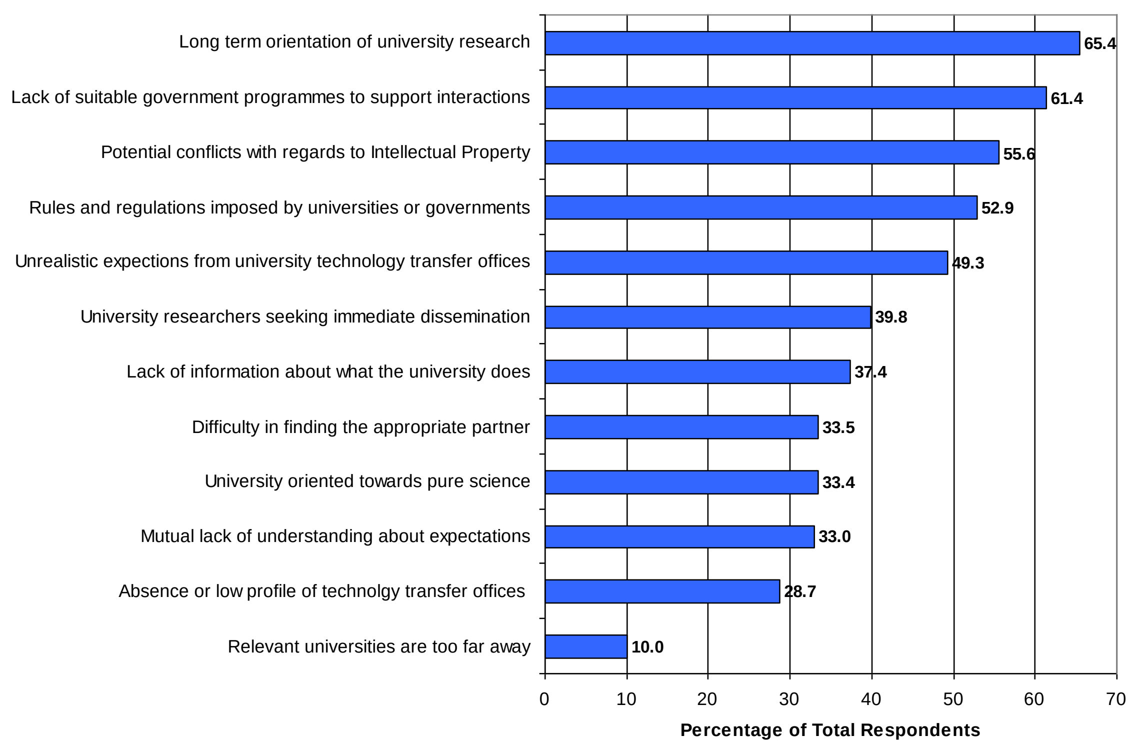
[7] The survey sample of 22,170 represents a response rate of over 17 percent from 125,900 individual academics in all disciplines in virtually all Higher Education Institutions in the UK. The sample encompassed all grades of staff: Professors (19 percent); Readers, Senior Lecturers, or Senior Researchers (30 percent); Lecturers, Researchers or Teaching or Research Assistants (42 percent); and other grades of staff (9 percent).

the general public by universities and governments, their role in technology transfer and commercialization through engagement with business is typically prominent.

2.3 Barriers to U-B Collaboration

It is not surprising that businesses and universities (and individual academics) have different perceptions on barriers to collaboration given that they have different motivations for collaborating. Figure 2 (below) and Figure 3 (next page) provide UK survey results on barriers to collaboration.[8]

Figure 2
UK Business Perceptions of Barriers to Interaction with Universities (2007-2008) Percentage of Respondents stating they "agree" or "strongly agree"

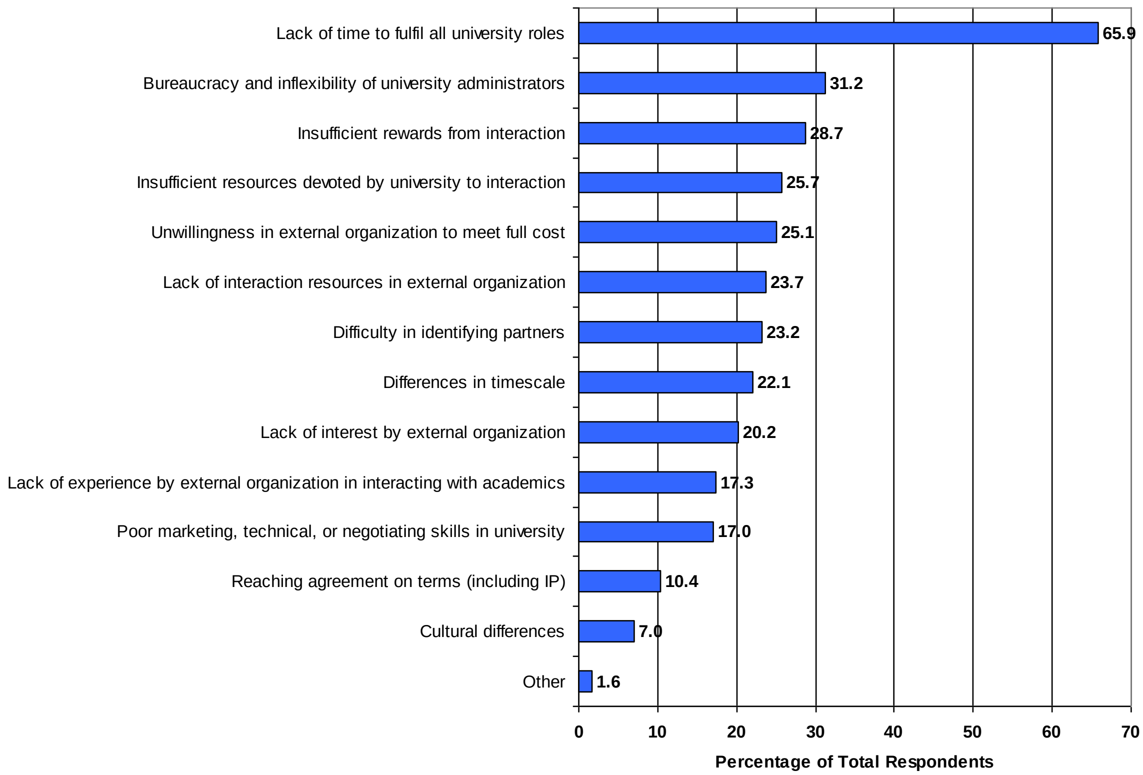


Source: Johan Bruneel, Pablo D'Este, Andy Neely, and Ammon Salter. 2009. "The Search for Talent and Technology – Examining the attitudes of EPSRC industrial collaborators towards universities."

Note: The survey covers firms collaborating with UK universities since 1999 through Engineering and Physical Sciences Research Council (EPSRC) grant programs.

[8] A comprehensive survey of barriers to U-B collaboration has not been carried out in Canada. The August 2010 survey of Québec based business conducted Board of Trade of Metropolitan Montreal and Léger Marketing did ask a general question on the subject but elicited a very low response rate (less than 30 responses).

Figure 3
UK Academic Perceptions of Constraints on Interactions with External Organizations Including Business (Percentage of Respondents)



Source: Maria Abreau, Vadim Grinevich, Alan Hughes, and Michael Kitson. 2009. "Knowledge Exchange between Academics and the Business, Public and Third Sectors." UK-Innovation Research Centre.

The UK business and academic survey data (Figures 2 and 3 above) show that:

- potential conflict over intellectual property rights is ranked as a significant barrier from a UK business perspective, but far less so from a UK academic perspective. As discussed later in this report, national circumstances and legislative frameworks are important in this area and the responses might be different in other jurisdictions; and

- UK academics identify a lack of time to fulfill all university roles as the most important barrier to engagement with external organizations, including the business sector. Many other surveys show that businesses, particularly smaller businesses, very typically identify financial and time constraints as being significant barriers to engaging in all innovation activities, including collaborative activities with external partners (Business Development Bank of Canada and Angus Reid, 2010a, Harris Interactive 2010, and the Australian Industry Group, 2010).

The UK survey (as well as results from other surveys in other jurisdictions) finds that the “long term orientation of university research” is a barrier to collaboration from the viewpoint of UK businesses. The authors of the Australian Industry Group’s report on the results of its 2010 survey of Australian businesses finds that other factors apart from increasing profitability are important motivations for businesses to collaborate with universities. Yet these authors are torn between a desire to see that U-B collaboration meets “commercial business expectations” more quickly and their concern with “short-termism” in Australia’s business culture for innovation. The authors of the report write:

> “The Review process identified that short-termism is one of the key inhibitors of achieving a culture that recognises the value of innovation. For public Australian businesses, the demands of share market expectations can lead to an over-emphasis on quarter-by-quarter results, which may make Australian companies more vulnerable in the long term to disruptive threats from new entrants and emerging international competitors.”(Australian Industry Group, 2010: 7).

It may be that business concerns over the long-term orientation of university research are not only misplaced but may run counter to business management and shareholder self-interest. Roger Martin, Dean of the Rotman School of Management at the University of Toronto, has long argued that large public corporations may be undermining shareholder value through too narrow a focus on meeting short-term expectations (e.g., as signaled through the stock market) rather than on real markets and investing in product, service and process innovation that drive improvements in productivity (Martin, 2003). From this perspective, U-B collaboration that involves long time-frames (although not indefinite time frames) may be a healthy tonic for business. Paradoxically perhaps, it can also be a driver of, and a competitive response to, the widely observed shortening of product and service development cycles: while companies may attempt to gain competitive advantage by offering new product and services faster than rivals, they survive by meeting customer needs.

Among the most interesting findings from the empirical literature on barriers to U-B collaboration are those reported by Bruneel, D'Este and Salter (2009). They investigate the effects of collaboration experience, breadth of interaction, and inter-organizational trust on lowering barriers to U-B collaboration. They report that orientation-related barriers (e.g. long term orientation of university research) and, to a lesser extent, transaction-related barriers (e.g. intellectual property rules and administrative processes for the conduct of research) become less important as the two sectors gain experience in engaging with one another. In essence, experience in U-B collaboration matters because organizations learn by doing, including overcoming at least some types of formal and informal barriers to collaboration.

2.4 Determinants of U-B Collaboration

Much of the empirical research on U-B collaboration focuses on business determinants for entering into research collaborations with universities rather than on university determinants. Business determinants commonly examined include: firm size; industry sector; stage and type of R&D; government support policies for business R&D; and proximity factors (geographic, linguistic and cultural).

2.4.1 Firm Size

The descriptive results from various national innovation surveys consistently show large firms are relatively more likely to collaborate with the higher education sector than are small and medium-sized enterprises (SMEs). Less than ten percent of SMEs, as proportion of all SMEs, collaborate with universities on innovation in many OECD countries except for Finland (OECD 2007a, 2009b).[9] In Canada, the authors of the August 2010 survey of Québec-based firms find that: "larger companies with deep pockets are more likely to collaborate with academia. In fact, it is significantly higher among companies with 250 or more employees (70%) and those with sales of $50 million or more (81%)." (Montreal Board of Trade, 2010: 10).

Empirical studies on firm size as a determinant of U-B research support these survey findings but present a more nuanced picture. Laursen and Salter (2003) and Fontana, Geuna and Matt (2006) find that, although firm size is an important structural determinant for U-B collaboration, it is not the only or always the most important determinant. They suggest that firms may enter into collaborative arrangements with universities or other public research organizations as a matter of managerial choice and information search and screening strategies.

Research on firm size as a determinant of firm propensity to collaborate with universities (or other firms for that matter) should be situated within the larger context of studies on the relationship between firm size, competition and innovation. One can go back to the work of Schumpeter for the view that large firms innovate more intensively than smaller firms, but firm size has generally not been found to be a robust predictor for innovation. Large firms do spend more in absolute terms on R&D than smaller firms, due to their size and greater profits, but they may not be intrinsically more innovative.[10] Small firms are generally found be more innovative per dollar of research and development (Sharpe and Currie, 2008). The public policy implication is that there is good reason for governments to focus on encouraging collaboration between smaller firms and universities and community colleges.

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[9] These results do not cover the US. The US Government initiated a national business innovation survey in January 2009 with full results available in 2011.

[10] Why large firms may not be intrinsically more innovative that smaller firms has been the subject of considerable research attention. For example, Auerswald et. al. (2005) suggest that barriers to in-core radical business innovations by large firms may include: incompatibility of the new product with existing production processes; the need for a radical change in business model; lack of familiarity with key technical knowledge by the product development teams; and concern about "fratricide" of existing products made obsolete by the radical, in-core innovation.

2.4.2 Industry Sector

The sectoral focus of U-B collaborations across national jurisdictions will likely differ because of variation in sectoral contributions to R&D across national economies (USG, 2010s: C4-29). There is limited information on the distribution of U-B research collaboration by industry sector in Canada (the results of Statistics Canada's 2009 *Survey of Innovation and Business Strategy*, as they become available, may help fill this gap[11]). Business R&D intensities by business sector in Canada may be one guide to the sectoral locations for U-B collaborations (see Table 3 below).

Table 3
R&D intensity by Business Sector in Canada 2007

Business Sector	SHARE OF BERD %	SHARE OF TOTAL GDP %	BERD INTENSITY (%)
MANUFACTURING	**52.7**	**15.1**	**3.59**
Computer and electronic products	18.5	0.6	31.72
Pharmaceutical and medicine	7.3	0.3	25.03
Aerospace products and parts	6.5	0.5	13.37
Machinery	3.6	1.1	3.37
Chemical, plastic and hydrocarbon products	3.3	1.2	2.83
Motor vehicles and part	3.3	2.0	1.70
Wood products, paper and printing	2.9	2.2	1.36
Fabricated metal products	1.4	1.2	1.20
Primary metals	1.3	1.0	1.34
Electrical equipment, appliances and components	0.9	0.3	3.09
Food, beverages and tobacco	0.9	1.9	0.49
Non-metallic mineral products	0.4	0.5	0.82
All other manufacturing	2.4	2.3	1.07
SERVICES	**42.3**	**69.2**	**0.63**
Information and cultural industries	10.6	3.6	3.03
Computer systems design and related services	8.0	1.1	7.48
Scientific research and development.	8.0	1.2	6.86
Wholesale and retail trade	5.2	11.8	0.45
Architectural, engineering and related services	2.7	1.0	2.78
Finance, insurance and real estate	2.3	19.9	0.12
All other services	5.5	31.8	0.18
ALL OTHER INDUSTRIES (primary, utilities, construction)	**5.0**	**15.8**	**0.33**
TOTAL ($ BN)	**$15.8**	**$1,536**	**1.03%**

Source: Council of Canadian Academies (CCA, 2009a: 90)

Note: Business Expenditures on Research and Development (BERD) intensities calculated as BERD as a percentage of value added (GDP) in the sector.

[11] Initial results from Statistics Canada's 2009 Survey of Innovation and Business Strategy were published in November 2010, but results of relevance to this report's subject matter will not be available until later in 2011.

It may be reasonable to assume, based on the R&D sectoral intensity data reported in Table 3 (above), that the most prominent sectoral locations for U-B research collaborations are health, information and communication technologies (ICT), and aerospace. A study on research contracts issued by Canadian businesses to universities (The Impact Group, 2010: 19) supports this assumption, as does descriptive data assembled by Rosa and Mohnen (2008) on all business funding of Canadian university research for the 1999-2001 period. Yet anecdotal evidence suggests that U-B collaboration in the primary industries of energy, forest products and agri-food is extensive in Canada, but this is not apparent from the R&D intensity rankings presented in Table 3 (above). Primary industry R&D expenditures are dispersed across a variety of sectors, including the ICT sector.[12]

2.4.3 Type and Stage of R&D

Preliminary results from the first ever US Business R&D and Innovation Survey, released by the US National Science Foundation (NSF) in 2010, show that US companies are as much "process" innovators (introducing one or more new or significantly improved method for manufacturing or production, logistics, delivery, or distribution and support activities) as they are "product" innovators. According to the NSF:

> "Around 47,000 of the estimated 1.5 million for-profit companies (3%) performed and/or funded R&D in 2008. …According to the survey data, 66% of all these companies were product innovators in the 2006–08 period, and 51% were process innovators. There is also indication that the companies with the most R&D (those in the $50–$100 million and $100 million or more annual R&D categories) report the highest incidence of innovation: 76% and 81%, respectively, for products in 2006–08, and 69% and 71% for processes." (USG, 2010*l*: 3)

These US findings lend support to those who suggest that we need to be more innovative in thinking about innovation and the sectors and disciplines that may become more important for potential U-B research collaboration in the future.

The traditional linear model of innovation conceives of universities as the location for basic research which is then translated through applied research to commercialization and application in the marketplace. This model suggests that firms will be most interested in drawing out new ideas and knowledge from their university partners. The linear model of innovation went out of fashion among some innovation policy analysts and commentators over the past decade. One influential study (based on US data from the late 1990s) by Cohen, Nelson, and Walsh (2002) found that:

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[12] Sharpe (2003) reports that: "Total R&D spending in Canada was 1.81 per cent of GDP in 2000. All natural resources industries had lower R&D/GDP ratios. This should not necessarily be seen as a concern for two reasons. First, the technological advances that natural resource industries incorporate into their production processes are generally developed in other sectors (equipment producers and government and university laboratories in Canada and other countries). Second, it is the pace at which natural resource industries adopt new technologies, not the rate at which they undertake their own R&D, that determines productivity growth." (Sharpe, 2003: 25).

> "Contrary to the notion that university research largely generates new ideas for industrial R&D projects, the survey responses demonstrate that public research both suggests new R&D projects and contributes to the completion of existing projects in roughly equal measure overall." (Cohen et. al., 2002: 1)

Professor Heather Munroe-Blum, Principal and Vice-Chancellor of McGill University and a member of the Canadian federal government's Science, Technology and Innovation Council, has said:

> "… the character of the innovation story has changed dramatically. Gone is the master narrative of the conveyor belt that carries a new idea in linear fashion from basic research to applied research to development to product. Today's innovation is a global web, in which ideas and people are in perpetual movement and flux." (Munroe-Blum, 2010).

Yet linear models or "narratives" of innovation have not been abandoned within academic studies, government policy statements, and major think tank reports. For example:

- Belderbos, Carreeb, and Lokshin (2004), through a regression analysis of results from the Dutch CIS survey, find university cooperation and competitor cooperation in R&D are instrumental in creating and bringing to market radical innovations and generating sales of products that are novel to the market. Etzkovitz and Goktepe (2005) advance an "assisted linear model of innovation."

- The US President's Council of Advisors of Science and Technology, in its November 2010 report to the President on energy technologies, states that: "Responding to the energy-related challenges of competitiveness, climate change, and security will require leadership across the energy innovation chain – from invention to diffusion – " and devotes an entire section to a discussion of "Filling the Innovation Pipeline." (USG, 2010p: 13-20). Dr. Francis S. Collins, Director of the US National Institutes of Health (NIH), states in his introduction his most recent Biennial Report to the US Congress that: "New partnerships between academia and industry promise to revitalize the flagging drug development pipeline." (USG, 2010a: 1)

- the US Kauffman Foundation released its report on clean energy innovation in November of 2010 and stated that: "To become a global competitor in the burgeoning clean energy industry, the United States must reform policies and practices all along the innovation pipeline, from research and development to deployment and adoption." (Kauffman, 2010).[13]

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[13] Arundel, Bordoy, Mohnen and Smith (2008) have suggested one possible explanation for a continued adherence to linear models of innovation: "…the countless announcements of the death of the science-push or linear model of innovation, based on R&D, and its presumed replacement with 'systemic' models using Schumpeterian definitions of innovation, are decided premature. In

It is likely that the most effective public policies to improve business innovation, including through encouraging U-B collaboration, will draw insight both from traditional and new ways of thinking about innovation. With respect to the former, Cohen, Nelson and Walsh suggest that linear models of innovation remain relevant for some industry sectors, particularly the pharmaceuticals sector:

> "There is no other industry where public research – and particularly a basic science (i.e., biology) – is thought to be so relevant. Also, knowledge from buyers and firms' own manufacturing operations are less important to R&D in pharmaceuticals than in other industries, suggesting that the linear model may characterize the innovation process better in this industry than in others."(Cohen et. al., 2002: 21)

Value should also be drawn from newer insights on innovation processes, perhaps especially those emerging from the field of behavioral economics.[14] Applied to our thinking about innovation in general, and U-B collaboration in particular (because, after all, U-B collaboration is about behavioral relationships), behavioral economics opens up new policy options for governments. For instance, it suggests that governments should support institutions that function to establish social trust, connectedness, and confidence between disparate groups and individuals from universities and business. But it also suggests, for example, that behavioral change is unlikely to be achieved through an ever greater number of detailed requirements as to how research dollars are to be spent (as suggested in later sections of this report, such requirements are typically imposed on universities).

2.4.4 Government Support for Business R&D

There is a long-standing economic debate over whether public funding of R&D increases private R&D or crowds it out and, in either case, to what extent. Many empirical studies on this subject suggest there is no single answer. It depends on such factors as sector, size of firm, form of government support (e.g. direct program

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fact, the science-push model based on R&D is probably the dominant model in use today by both academics and the policy community. Its continued success is partly due to its successful incorporation of many of the features of modern innovation theory. These include shifting final outputs from patents to market indicators and evaluating the effect of a range of business strategies. The disadvantage is that this model largely ignores innovation that is not based on R&D." (Arundel et. al, 2008: 4). A more prosaic explanation may lie in the fact that linear models, at least as they are portrayed to the general public in public policy documents and statements, are easier to communicate even as they simplify great complexity in innovation structures and relationships.

[14] Economist Robert Shiller has observed that: "Today, modern behavioral economics is suggesting new ways of encouraging better economic decision making without necessarily making the plans mandatory. These new ways of handling the problems that interfere with good decision making are grounded in behavioral research, that is, in the barriers to individual success in economic decisions." (Shiller, 2005: 16).

spending or tax credits) and longevity of government support (see Czarnitzki and Fier, 2004, for a literature review and analysis).

There are fewer studies on whether businesses who receive government research incentives/subsidies are more likely to collaborate with universities and other public research institutions. Hanel and St-Pierre (2006) find that public R&D subsidies are positively correlated with the propensity of Canadian manufacturing establishments to collaborate with universities, but they also state:

> "This is not surprising because certain programs directly aim at fostering the collaboration with a university. However, we should be aware that when a firm asks for an R&D grant and organizes their research activities, including that of collaboration, according to program eligibility criteria, then the causality is reversed." (Hanel and St-Pierre, 2006: 496).

A number of businesses, think tanks and other organizations in the US, the UK and Canada have supported the introduction of special tax credits for U-B collaboration (e.g., that are in addition to generally available R&D tax credits), including: the Conference Board of Canada (2006); the Canadian Chamber of Commerce (2007); the US President's Council of Advisors on Science and Technology (USG, 2008f); the New York Governor's Task Force on Industry-Higher Education Partnerships (2009); and the Scottish Science Advisory Council (2009).[15] Even so, a robust evidence base has not yet been established to support the creation of such credits (Czarnitzki, 2009). The European Commission's Expert Group on R&D Tax Incentives reported to the European Commission in 2009 that:

> "Tax incentives for industry-science R&D cooperation have not been evaluated in depth. Little is known about whether they actually target market failures reasonably precisely, to which degree they have a crowding out effect, and to which degree they bring universities and businesses closer together in a beneficial manner worthy of the extra support from society. In addition, little is known about the transaction costs in cooperative projects, and thus how generous the support through the tax scheme should be to achieve the desired effects. On this basis the expert group suggests that an evaluation of tax incentives for business-university cooperation… [be] initiated. The expert group believes that this possibly could be a joint evaluation for several European countries that have such special schemes in place."(EC, 2009b: 20).

[15] In 2007, the Canadian Chamber of Commerce recommended that: "The government should also consider expanding the ITC for collaborative R&D. Firms are likely to under invest in collaborative research (whether in partnership with a university, national laboratory, or industry consortium) because it tends to be more basic and exploratory. Moreover, research results are shared and firms cannot capture the full benefits… Countries like Norway, Spain, the UK, Denmark, Hungary and Japan provide firms tax incentives/deductions for collaborative R&D." In Canada today there is a larger debate taking place over the future of the existing federal R&D tax credit. (See section 4.3.1.1 of this report for a discussion of Canadian circumstances and policy implications).

One important area for future research is the extent to which R&D tax incentives specifically targeted at encouraging U-B research collaboration may cause firms to reallocate their own internal R&D expenditures to external performers.

Paff and Watkins (2009) have made an initial contribution in this area. They focus on the bio-pharmaceutical and software industries in California and Massachusetts, where tax credit rates changed differently over time (1994-1999) for the two types of R&D.[16] They examined changes in the composition of firms' R&D budgets between in-house R&D and external basic research when the relative tax prices of each category of research change and report evidence of a substitute relationship both for a sample comprising exclusively small firms as well as for a more general distribution of firm sizes in the two US states. They conclude:

> "For policymakers, the finding of R&D substitution also suggests limited net increases in overall R&D effort by these small firms in response to more favorable tax credits for funding external contract research. The firms, on average, shift away from in house R&D when faced with lower relative prices of external contract research. If they completely offset, then unless university-based research is more socially valuable there is little reason in terms of the overall R&D pie for the differences between R&D tax credit rates on the different types of R&D, such as those in California and Massachusetts, except political expediency in attracting private funding for universities and similar non-profits." (Paff and Watkins, 2009: 225).

The Paff and Watkins findings do not necessarily undermine the empirical findings by other studies (e.g., Cassiman and Veugelers, 2006) that internal and external R&D by a firm are complementary activities.[17] However, they do draw attention to the potential limitations of tax credits to encourage U-B research collaboration. This is a matter that we shall return to in Section 4.3.1.1 of this report on Canadian circumstances in the matter of choosing between using R&D tax credits and direct program spending to encourage U-B research collaboration.

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[16] The authors explain that: "although the [US] federal tax credit rate is the same (20%) for both forms of research, several states provide a significantly higher credit rate for external contract research. For example, in 2002 California's external contract research credit was 24% with a QRE [Qualified Research Expenditure] rate of 15%; in Massachusetts the rates were 15% and 10% … This suggests state-level policymakers want to encourage firms to increase investment in basic science… However, it may not have been their intention for firms to increase industry-sponsored university research by decreasing in-house R&D—substitution of external for internal R&D in response to relative tax prices.' (Paff and Watkins, 2009: 208).

[17] Cassiman and Veugelers (2006) conclude: "Our results are consistent with the existence of complementarity between internal and external innovation activities. Therefore, innovation management requires a tight integration of internal and external knowledge within the firm's innovation process to capture the positive effects each innovative activity has on the marginal return of the other. More importantly, our analysis reveals that the extent to which the innovation process relies on basic R&D affects the strength of the complementarity between innovation activities. Hence, complementarity is context specific." (Cassiman and Veugelers, 2006: 80).

2.4.5 Proximity (geographic, cultural, linguistic)

Geographic proximity influences the propensity for universities and businesses to collaborate both within and between countries. The Australian House of Representatives' *Report on International Research Collaboration* finds that, for Australia, the tyranny of distance is all pervasive, "…even impacting on the ability of Australian researchers to cooperate with their international colleagues, and it is a problem that will have to continue to be managed by Australian researchers." (CGOA 2010j: 12). De Backer, López-Bassols and Martinez (2008), in their review of the academic literature, report that:

> "…the choice of innovation partners seems still to privilege those that are geographically close. Despite highly improved communication possibilities, collaboration with external partners requires extra investments and resources especially on an international level. This may explain why SMEs, which typically have fewer resources, display a lower intensity of collaborating with external parties, overall and internationally."(De Backer et. al., 2008: 18)

Rosa and Mohnen (2008) examine payments for R&D services from all Canadian business enterprises to Canadian universities in the 1997-2001 period. After controlling for a variety of explanatory variables, they find that if the geographic distance between a business enterprise and a university increases by ten percent, the fraction of the total R&D expenditures of that enterprise directed to that particular university decreases by just over one percent.[18]

Cultural and linguistic proximity has also been found to influence the extent of U-B collaboration. A literature review conducted by the European Commission's Observatory of European SMEs finds that:

> "Linguistic barriers and differences in mentality and institutional distance matter. Language, laws and diverse national regulations favour innovation co-operation with partners from the firms' own region or nation. Firm managers are often familiar with regional and national R&D institutes due to earlier experience, but are unfamiliar with the institutional setting abroad. Thus, in spite of the European efforts for integration and several cross-border initiatives, national innovation systems with their regulations and institutional settings are still important for firms' innovation interactions…"(EC, 2002: 26).

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[18] Rosa and Mohnen include in their study all Canadian enterprises investing in more than C$ 1 million in R&D during the 1997 through 2001 period. They report differences in the magnitude of the distance affect depends on whether the business enterprise is primarily engaged in codified (e.g. licencing and patenting) or uncodified knowledge exchange activities: "As expected, the marginal effect of distance is greater in the case of enterprises with only tacit knowledge flows."(Rosa and Mohnen, 2008: 16).

The importance of proximity, geographic or other, for business to collaborate with universities or others is one of the premises for the development and advocacy of cluster policies by many OECD national and sub-national governments. Davis et. al. (2006) find that a number of commonly accepted characteristics of clusters have emerged: firms are linked through traded and untraded relationships with each other; interlinked firms are geographically proximate; and clusters encompass a mix of public and private organizations, including universities, other public research institutions, suppliers, and providers of business services, which provide specialized skills and infrastructure of value to the cluster. But some observers consider that "clusters" are not a conceptually sound basis for policy making whether with respect to encouraging U-B collaboration or to achieve other policy objectives (Martin and Sunley, 2002).[19]

The importance of geographic proximity as a determinant of U-B collaboration is not inconsistent with the increasing internationalization of R&D.[20] The OECD (2008c) reports that R&D performed abroad has increased since 1995 relative to R&D performed at home in a number of OECD countries. U-B collaboration is presented in some studies as a prominent feature of R&D internationalization as multinational

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[19] Ambiguity surrounding the role of public policy for cluster development is well illustrated in the October 2010 statement by the Coalition for Action on Innovation in Canada, co-chaired by the President of the Council of Chief Executives, the Honourable John Manley, and Paul Lucas, Chief Executive Officer of GlaxoSmithKline Canada. The Coalition said: "There is no single or simple recipe for creating and developing innovative clusters; some emerge from local networks of small- and medium-sized firms, while others rely on a keystone company or post-secondary institution that acts as an anchor by spinning off new businesses and attracting investment. A strong business and research environment, a plentiful supply of specialized labour and a range of government policies all are important. But local factors play key roles in cluster development, and framework policies therefore must be flexible." (Coalition for Action on Innovation in Canada, 2010: 6).

[20] Claims respecting the increasing "internationalization" of R&D should be kept in proper perspective. First, R&D internationalization it is not truly "international." The majority of OECD R&D investment abroad goes to other OECD countries. The majority of R&D investment by OECD countries in non-OECD countries goes to China and India. (USG 2010s: C4-49). Second, and at least with respect to US companies, the majority of their R&D expenditures continue to be made at home. Among the first findings from the 2009 US Business R&D and Innovation Survey (BRDIS) is that: "Companies located in the United States that have research and development activities — both U.S.-owned businesses and U.S. affiliates of foreign parents — reported worldwide sales of $11 trillion in calendar year 2008 and worldwide R&D expenses of $330 billion. Most ($234 billion) of that R&D expense was for R&D conducted in companies' own facilities in the United States."(USG, 2010y: 1). On the other hand, Robert D. Atkinson, a US commentator on innovation policy, has testified before that US Congress that: "… over the last decade, the share of U.S. corporate R&D sites in the United States has declined from 59 percent to 52 percent, while the share in China and India increased from 8 to 18 percent. Taken together, it is clear that the U.S. private sector engine of innovation is not working as well as it used to." (Atkinson, 2010: 5).

firms seek local access to high quality research universities in establishing R&D facilities abroad as well as at home.[21]

In 2005 the Government-University-Industry Research Roundtable of the US National Academies of Sciences commissioned a survey of over 200 multinational companies across 15 industries on the factors that influence decisions on where to conduct R&D. Among 13 possible factors, survey respondents ranked "ease of collaborating with universities" and "university faculty with special scientific or engineering expertise" as being among the most important. (Thursby and Thursby, 2006: 2). The results from more recent and industry sector specific surveys on factors influencing international R&D are consistent with the Thursby and Thursby survey findings (e.g., Semiconductor Industry Association, 2009).

There is empirical research that supports the survey findings. For instance, Belderbos, Leten and Suzuki (2009) examine the role of host countries' academic research strengths in global R&D location decisions by multinational firms. The authors consider the foreign R&D activities in 40 host countries and 30 technology fields by 176 European, US and Japanese firms during the periods 1995-1998 and 1999-2002. They find:

> "… the probability to conduct R&D abroad by firms is positively affected by host countries' academic research capabilities, after controlling for a broad set of other host country characteristics that attract or discourage inward R&D. …In host countries with low academic research capabilities, the probability that science oriented firms will conduct R&D is close to zero as scale and scope economies appear to favor concentration of science oriented R&D at home. In contrast, science oriented firms show the highest propensities to conduct R&D abroad in host countries with the strongest academic record. This pattern appears most pronounced in the most recent period 1999-2002." (Belderbos et. al, 2009: 29).

Governments are seeking to capture the benefits from R&D internationalization, including through measures to encourage U-B collaboration. In this context, UNCTAD's 2005 *World Investment Report* describes how R&D internationalization opens up opportunities for countries to access technology, build high-valued added products, develop new skills, and generally strengthen their national innovation systems. But the UNCTAD report also states that:

> "… the transnational expansion of R&D may give rise to concerns in home countries, especially with regard to the risk of hollowing out and the loss of jobs. …it does seem that protectionist measures to limit the expansion of R&D abroad will not effectively address these concerns as they would risk undermining the competitiveness of the country's enterprises. Rather, to turn the internationalization process into a win-win situation for host and home countries alike, policies aimed at advancing the specific innovation capabilities and the

[21] See Annex II for a discussion of "open innovation" and U-B collaboration.

> functioning of the NIS [National Innovation System] are key." (UNCTAD, 2005: F29).

One public policy question arising from UNCTAD's observation is whether government measures to encourage U-B collaboration are helping or hindering the generation of UNCTAD's "win-win situation for host and home countries alike"?

2.5 Measurement

There are four categories of commonly cited indicators for measuring and reporting on U-B collaboration:

- research funding indicators;
- bibliometric indicators (e.g., trends in university-business co-authorship);
- technology transfer and commercialization indicators (e.g., patenting, licensing, creation of university-spin off companies); and,
- other survey and composite indicator results.

Indicators within these categories have strengths and limitations, are subject to a variety of interpretations, and give rise to further research questions. One limitation is that many are quite narrow and provide limited insight into U-B collaboration in fields other than R&D activities.[22]

2.5.1 Research Funding Indicators

One point to be borne in mind when considering indicators of business funding of research in the higher education sector as a proxy for U-B collaboration is that we do not know what the "optimal" level of business investment in university research may be and, if only by implication, what the "optimal" level of U-B collaboration in research may be. In this context, the Australian Productivity Commission's observations on the use of R&D funding ratios are relevant:

> "[R&D] ratios often assume an iconic status as 'proof' of endemic underinvestment in business R&D in Australia, especially among those wishing to attract more funding. However, comparisons of input ratios are usually a conceptually unsound basis for assessing optimal investment in R&D. Nothing says that 'high' input ratios are necessarily better than 'low' ones, since it is possible to both under- or over-invest in R&D. For most other inputs – such as

[22] Arundel and O'Brian (CGOA, 2009g: 53) observe that many firms do not innovate solely through R&D or through technology adoption - there is a continuum of creative activities between these two end points.

> labour or capital – the usual interest is not in maximising inputs per output, but rather maximising its inverse (output per input or productivity)." (CGOA, 2007b: 43).

A related point is that market forces do not always function to define optimality of business investment in university research.[23] Some observers believe that it is public investment in research (including at universities) that drives the level of private investment. Professor Steve Smith, President of Universities UK, has stated:

> "…All the international and UK evidence points to one inescapable conclusion: in R&D, it is governmental spending that leverages out private sector spending and is a magnet for private investment and, for inward investment. Reducing governmental R&D spending thus starts a vicious circle, leading not to replacement private R&D spending but to reductions in private spend. This leads to a downward spiral as charities and businesses react by moving their investment to our competitors." (Smith, 2010).

Keeping these viewpoints in mind, the following discussion considers two research funding indicators: the share of total research expenditures performed in the higher education sector that is funded by the business sector; and the share of total business R&D expenditures that is allocated to the higher education sector.

Share of total research expenditures performed in the higher education sector and funded by the business sector

R&D performed in the Canadian higher education sector and funded by the business sector grew from C$ 460.3 million in 1999-2000 to C$ 892.4 million in 2008-2009 (current dollars) but has exhibited no substantial growth in real terms over the past five years (GOC, 2010r). Business funding of Higher Education Research and Development (HERD) has remained under 10 percent of total HERD over the past ten years.

Over the same period, total funding of HERD from all sources grew from C$ 5.1 billion to C$ 10.9 billion. The largest increase in funding of HERD came from the federal government. The federal government's share of total HERD grew from 21 percent in

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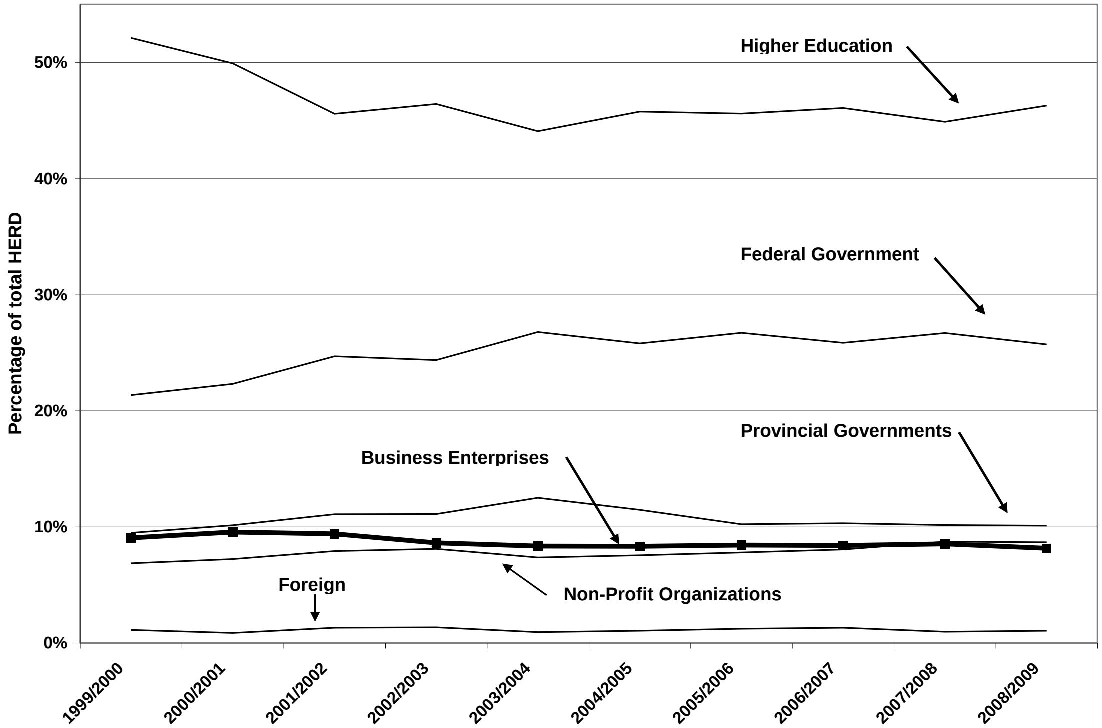
[23] According to The Impact Group (a Canadian consultancy), one area where market forces may have a larger role to play is in research contracted out to the university sector by the private sector: "Research contracting is a pure form of "demand-driven" research. Organizations external to the research institution willingly pay money in return for specified research knowledge. Research contracts come with an in-built receptor - the contracting organization - which stands ready to apply the knowledge."(Impact Group, 2010: 115). However, they also state that: "Evidently, third party funding of university/hospital research is an important consideration, at least for a sub-group of companies. Both NSERC and CIHR have funding programs that actively support collaborative research between private sector firms and universities. Anecdotal evidence is that companies value these programs and in many instances rely on them to increase the reach of their in-house research." (The Impact Group, 2010: 107).

1999-2000 to between 26 and 27 percent after 2000-2001 (see Figure 4 below). In 2008, Canada had the 5th highest HERD to GDP ratio in the OECD (0.64 percent compared to: 0.53 percent in Australia, 0.47 percent in the UK, 0.36 percent in the US).

Figure 4
Source of Funds for R&D Performed in Canada's Higher Education Sector 1999/2008 to 2008 /2009



Source: Statistics Canada Catalogue 88-001-X (September 2010).

How does Canada compare to other countries as measured by the share of total research expenditures performed in the higher education sector and funded by the business sector? Here there is a critical challenge in the international comparability of HERD funding statistics (Pouris, 2007, Godin, 2008, the AUCC, 2008, Hamdani, 2009, and Gault, 2010). Differences in measuring HERD across national jurisdictions include: institutional thresholds for reporting; coverage of disciplines; definition of the higher education sector; treatment of capital expenditures (unlike many other jurisdictions, the US National Science Foundation does not include capital expenditures on R&D when it reports higher education research and development expenditures to the OECD); and, accounting for the institutional (indirect) costs of research (according to the AUCC (2008), the US reports to the OECD on organized or externally funded R&D but does not include research that is financed from internal university sources unless that research is formally budgeted by the university department).

Keeping these and other reporting differences and data collection practices in mind, Table 4 (below) presents the available data on business funding of HERD as a share of total HERD across OECD jurisdictions.

Table 4
Percentage of Higher Education Expenditure on R&D (HERD) Financed by Industry

Country	1995	2003	2004	2005	2006	2007	2008	Average 2003-2008
Turkey	13.1	20.8 [o]	21.6 [o]	22.7 [o]	23.8 [o]	23.3 [o]	17.4 [a]	21.6
Korea	22.4 [g]	13.6 [g]	16.1 [g]	15.2 [g]	13.7 [g]	14.2 [a]	12.0	14.1
Germany	8.2	12.6	13.2	14.1	14.2	14.2 [p]	..	13.7
Hungary	2.1 [v]	10.6 [v]	12.9 [v]	11.8 [v]	13.0 [v]	13.7 [v]	14.7 [v]	12.8
Iceland	5.4	9.5	..	11.3	12.7	13.7	13.7 [p]	12.2
Belgium	13.1	11.6	10.0	10.9	11.3	11.1	..	11.0
Canada	**8.0**	**8.3**	**8.3**	**8.4**	**8.4**	**8.5**	**8.5** [p]	**8.4**
Greece	5.6 [a]	7.5	..	8.9	..	..	..	8.2
Switzerland	..	..	8.7	..	8.7	..	6.9	8.1
Spain	8.3	6.4	7.5	6.9	7.9	9.0	..	7.5
Netherlands	4.0	6.8	..	..	..	7.5 [a]	..	7.2
Finland	5.7	5.8	5.8	6.5	6.6	7.0	7.2	6.5
Australia	**4.7**	**..**	**6.2**	**..**	**6.7**	**..**	**..**	**6.5**
Poland	11.4	6.0	5.6	5.4	5.4	11.3	3.8	6.3
New Zealand	9.4	7.3	..	8.0	..	3.1	..	6.1
United States	**6.8** [i]	**5.3** [i]	**5.1** [i]	**5.1** [i]	**5.4** [i]	**5.6** [i]	**5.7** [i]	**5.4**
Sweden	4.5 [a,j]	5.3	..	5.1	5.1	4.9	..	5.1
Austria	..	..	4.5	..	5.0	5.7	..	5.1
United Kingdom	**6.3**	**5.2**	**4.9**	**4.6**	**4.8**	**4.5**	**4.6**	**4.8**
Norway	5.3	5.0	..	4.7	..	4.0 [a]	..	4.6
Japan	2.4 [m]	2.9	2.8	2.8	2.9	3.0	3.0	2.9
Ireland	6.9 [c]	3.0	2.6	2.7	1.8	2.3	4.2	2.8
Slovak Republic	1.0 [o]	0.0	0.6	0.7	4.7	6.8	2.5	2.6
Denmark	1.8	2.7	3.0	2.4	2.5	2.1	2.2 [c]	2.5
France	3.3	2.7	1.8	1.6	1.7	1.6 [p]	1.6 [p]	1.8
Mexico	1.4	2.0	0.9 [c]	1.2 [c]	1.5	1.3	..	1.4
Portugal	0.9 [a]	1.5	1.3 [c]	1.2	1.3 [c]	1.4	..	1.3
Italy	4.7	..	..	1.4 [a]	1.2	1.3	1.1	1.3
Luxembourg	..	..	..	1.4	..	1.1	..	1.3
Czech Republic	2.0 [a]	1.0	0.6	0.8	0.7	0.7	0.6	0.7
Chile	..	..	..	..	..	..	..	
EU27	6 [b]	6.6 [b]	6.5 [b]	6.6 [b]	6.7 [b]	6.8 [b]	.. [b]	6.6
OECD-Total	**6.2** [a,b]	**6** [b]	**6.1** [b]	**6.2** [b]	**6.3** [b]	**6.6** [b]	**..** [b]	6.2
China	**..**	**35.9** [v]	**37.1** [v]	**36.7** [v]	**36.6** [v]	**35.1** [v]	**34.6** [v]	**36.0**

Source: OECD Main Science and Technology Indicators Vol. 2010/1. Presentational adjustments and calculation of 6 year average have been made by this author.

Note: See source document for references to standard OECD footnotes.

There is considerable variation in business funding as a share of total HERD across the jurisdictions reported in Table 4 (above). For example:

- Canada's eight percent share is higher than the OECD average of between six and seven percent over the past decade;

- in the US the share of HERD funded by business peaked at 7.4 percent in 1999, declined to a low of 5.1 percent in 2004, but recovered to 5.7 percent by 2008;

- in Australia, the share of HERD funded by business as and as reported by the OECD was 6.7 percent in 2006.[24] This share declined to 4.9 percent in 2008.

- in the UK, the share of HERD funded by business was 4.6 percent in 2008, a share that has remained fairly constant over the past six years;

- Turkey's five year average share of HERD funded by business is the highest within the OECD at just under 22 percent. However, according to an expert from the Technopolis consulting group, this reported share may reflect the reporting practices employed by Turkey's national statistical agency. [25]; and,

- China (not a member of the OECD) also has a higher than OECD average reported share. This too may be traced to China's data reporting practices, although other factors (e.g. the transfer of a number of China's Public Research Institutes to the private sector) may be influential. (OECD, 2008d: 207).

Figure 5 (next page) illustrates differences in the percentage of HERD financed by business between OECD countries when taking into account differences in the size of national economies. R&D funded by the business sector and performed in the university sector is higher in Canada than in the US, the UK, Australia and most other OECD countries. When measured as a share of GDP, business investment in university research is: 0.06 percent of GDP in Canada; 0.02 percent in the US and the UK, and 0.03 percent in Australia.

Further research is required to determine if the gap between Canada and other OECD countries in the share of business funding of HERD would be significantly diminished after taking into account different data collection and reporting practices. (Research undertaken by the AUCC suggests the gap between Canada and the US in total HERD measured as a percentage of GDP would be considerably diminished if the US moved to Canadian HERD reporting practices (AUCC, 2008)).

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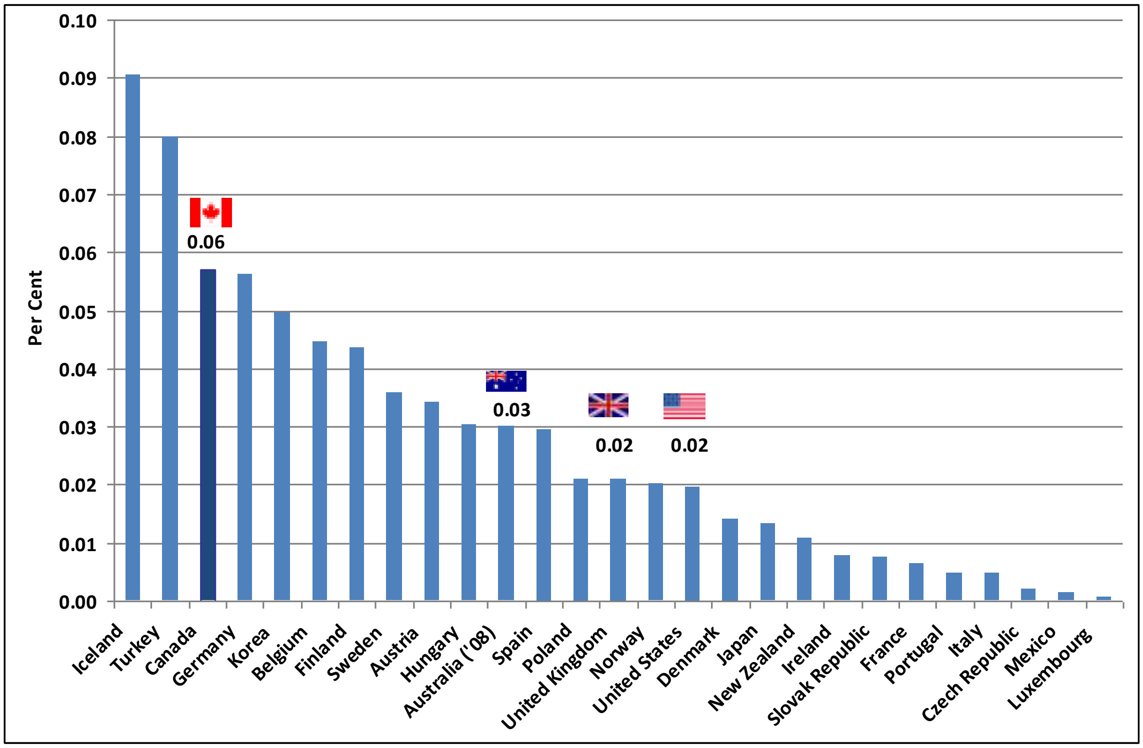
[24] The Australian Bureau of Statistics has recently revised the 2006 data and reports that the business share of HERD in 2006 was 6.1 percent (CGOA, 2010f: 11).

[25] Mr. Ihsan Karatayli, Senior Consultant, Technopolis Group, Turkey (correspondence with the author).

Figure 5
R&D Funded by the Business Sector and Performed by the Higher Education Sector, 2007, percentage of GDP (2008 for Australia)



Source: Centre for the Study of Living Standards based on OECD data. Australian data is for 2008 as reported by the Australian Bureau of Statistics, May 2010.

In summary, the trends reported above lend some support to the propositions that:

- large government investments in research performed in the Canadian higher education sector do not appear to have markedly "leveraged out private sector funding" for research performed in the higher education sector. Canadian business funding of HERD has flatlined over the past decade in constant dollar terms and as share of total HERD; but even so,

- Canadian business funding of HERD in an international context provides no evidence to suggest that Canada is lagging behind other jurisdictions. Canada may even be leading the US, the UK and Australia by a considerable margin (although here one must be cautious because of data comparability issues).

As one now turns to examine business research funding of HERD from a different perspective, there are many reasons, and not only reasons relating to weaknesses is the international comparability of the data, for why Canada cannot take any large degree of comfort from the indicator of business funding of HERD in an international context.

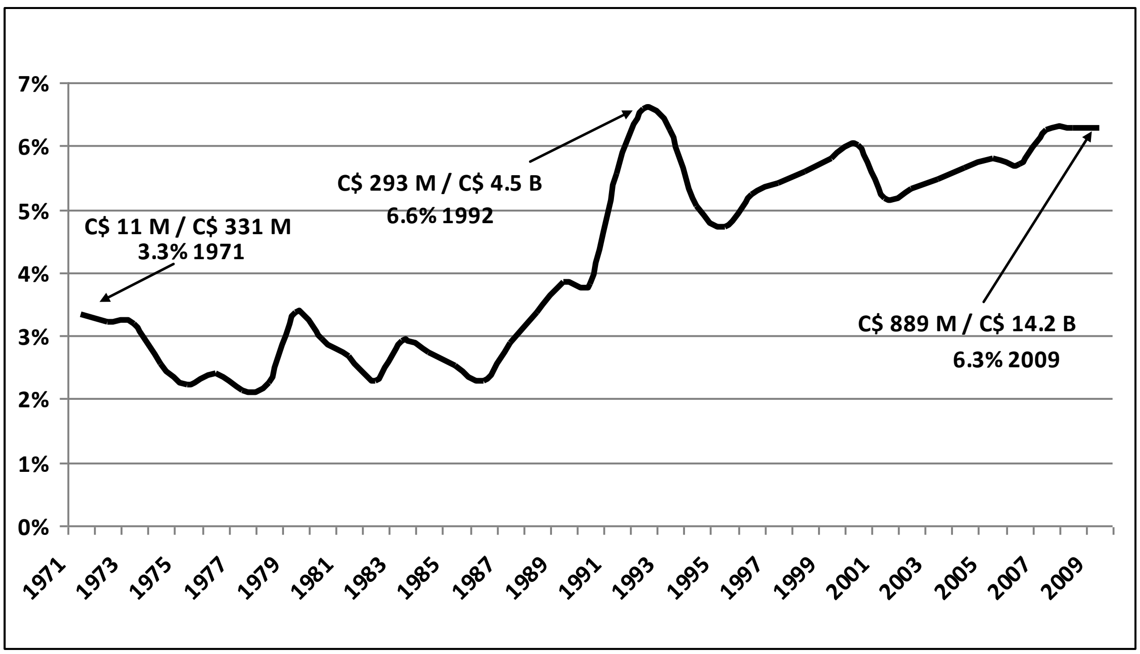
Share of Total Business R&D Expenditures allocated to Research Performed in the Higher Education Sector

Figure 6 (below) portrays the share of total Canadian Business Expenditures on Research and Development (BERD) performed by the Canadian higher education sector for the period 1971-2009. Two descriptive points are to be drawn from Figure 6:

- Canadian businesses have allocated an increasing share of their expenditures on R&D to the higher education sector over the past four decades: rising from a 3.3 percent share in 1971 to a 6.3 percent share in 2009; and,

- there was a major increase in the share allocated to the higher education sector in 1992 (to 6.6 percent), a fall-off thereafter, and only in 2008-2009 did the share again approach the 1992 peak.

Figure 6
Share of Total Business Sector R&D Funding Performed by the Higher Education Sector in Canada 1971-2009



Source: Centre for the Study of Living Standards based on Statistics Canada annual data (Extracted from CANSIM November 2010).

There are many questions to be pursued in order to increase our understanding of the Canadian funding trends portrayed in Figure 6, including:

- do they reflect that Canada may have underachieving denominator (BERD) rather than an overachieving numerator (business funding of HERD)? In 2008, BERD as a percentage of GDP was 1 percent in Canada: 1.22 percent in Australia; 1.10 percent in the UK; 2.01 percent in the US; and an average of 1.63 percent across the OECD (OECD, 2010a); and,

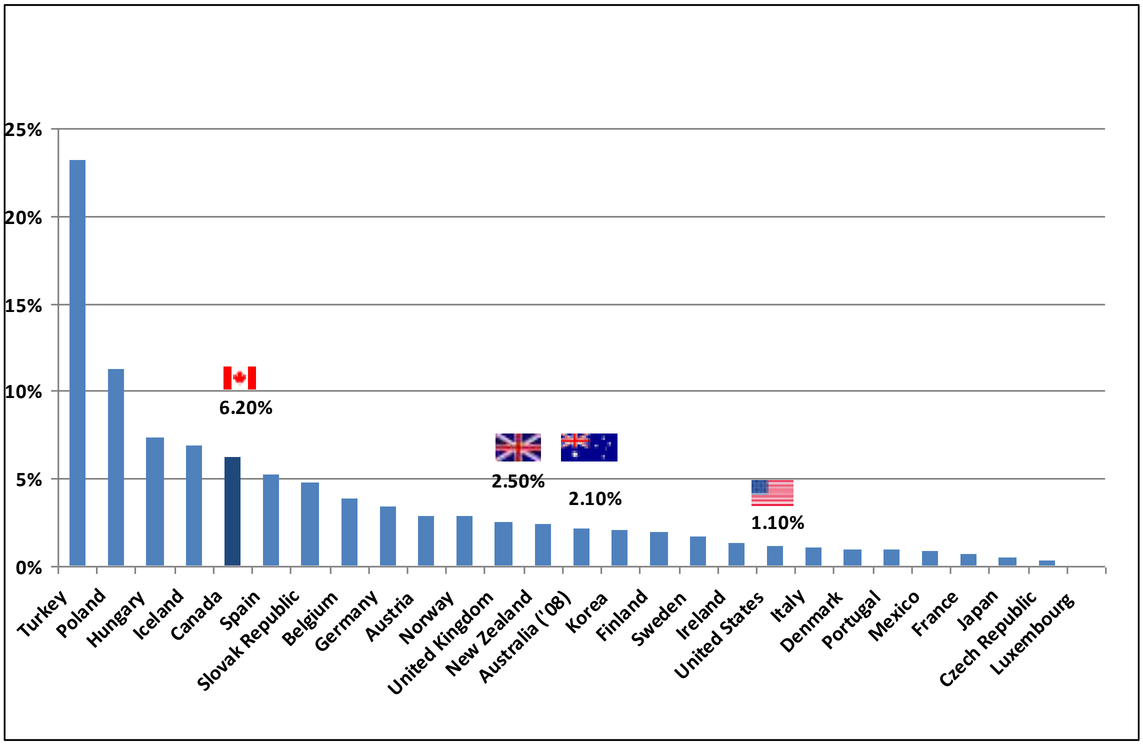
- how may a small number of major industry-university research projects impact overall trends? Doutriaux and Barker (1995) report that, in 1992, an influx of pharmaceutical industry funds, mainly to Québec universities, explains the noticeable rise in industry-sponsored R&D at universities. A small number of large companies account for the major proportion of R&D spending in Canada and, quite likely, for the funding of R&D in universities. (Statistics Canada reports that 75 firms accounted for almost half of total Canadian industrial R&D expenditures in 2009 (GOC, 2010k)).[26]

- is it possible to attribute the reported trends to specific public policy interventions? In the case of Canada, can the reported trends be attributed to: changes in the intellectual property regime for pharmaceuticals beginning in 1987 (see section 4.5.2 of this report); any one of multiple changes in tax incentives for the conduct of research and development in Canada over the entire period (see section 4.4.3.1 of this report); or the implementation of the Canada-US Free Trade Agreement (beginning in 1989) and the North American Free Trade Agreement (beginning in 1994) that increased competitive pressures and may have influenced business R&D spending trends in Canada, including their spending on research in the higher education sector?

Figure 7 (next page) presents the share of total BERD performed in the higher education sector for OECD countries in 2007 (and Australia for 2008).

[26] Statistics Canada counts of R&D performing firms in Canada has significantly increased over the past decade: from 9,967 in 2000 to 22,314 in 2007. However, Statistic Canada's annual survey of R&D performers relies heavily on administrative data drawn from the Canada Revenue Agency, including the number of companies claiming and receiving approval for their SR&ED tax credit claims. Several different explanations have been put forward for this increase (Gault, 2010 and Freedman, 2008). In particular, Freedman suggests that: "The sharp rise in the apparent number of industrial R&D performers from 2000 onward is probably a consequence of multiple factors: changes in the SR&ED program guidelines to allow a broader range of eligible claims (e.g. software); reduced oversight and less stringent standards of claims assessment on the part of CRA; increased "marketing" of the program by CRA and others.; and the growth of the SR&ED consulting industry." (Freedman, 2008: 11).

Figure 7
Share of Total Business Sector R&D Funding Performed by the Higher Education Sector 2007 (2008 for Australia)



Source: Centre for the Study of Living Standards based on OECD data. Australian data is for 2008 as reported by Australian Bureau of Statistics, September 2010.

The differences in the share of total business R&D expenditures that is allocated to the higher education sector across OECD jurisdictions (as well as the other national and international research funding indicators reported earlier in this section) give rise to at least two further questions deserving of research:

- what is the impact of the sectoral composition (and R&D intensity) of an economy? This may be a powerful explanatory factor both with respect to the contribution of BERD to HERD (and, by implication, the level of U-B collaboration) and also for the level of BERD itself within any given jurisdiction; and,
- is there a causal relationship between public and private funding of HERD? If so, what is the nature and intensity of that relationship? Should fiscal constraints on national and sub-national governments over the coming decade result in a substantial decline in public resources for university research, then will the existing level of business investment in university research also fall?

2.5.2 Bibliometric Indicators

Bibliometric studies measure the output of individuals/research teams, institutions, and countries in different disciplinary fields, including science and technology. They are based on the number and other features of publications, articles and citations. Bibliometric studies show that the level of research collaboration in science and technology fields (between authors, or countries, or disciplinary sectors, or societal sectors) has increased over the past twenty years (USG, 2010s: C5-34). But there are relatively few bibliometric studies that measure research output from U-B research collaborations. Lebeau, Laframboise, Lariviére and Gingras (2008) and Tijseen, van Leeuwen and van Wijk (2009) have made notable contributions to this smaller set of studies.

Lebeau et. al. (2008) report that in Canada the number of publications carried out in university-industry collaborations (co-authored papers) increased almost continuously from 203 in 1980 to 934 in 2005. They find that less than 15 percent of industries' papers were written with colleagues in universities in 1980 but this share reached 55 percent in 2005. (Lebeau et. al, 2005: 229). Should this finding hold for the period after 2005, then the share of Canadian industry papers written in collaboration with universities has exceeded levels found in the US in 2008. Citing studies using different data sets, the US National Science Board reports that, in the US, the share of total industry papers written with an academic institution increased by 9 percent points between 1998 and 2008, from 44.8 percent to 53.8 percent (USG, 2010s: C5-41).[27]

Tijseen, van Leeuwen and van Wijk (2009) explore university-industry co-publication (UIC) output from 350 of the world's largest research universities for the period 2002-2006 and based on Web of Science indexed publications. The authors state that their findings are first approximations and should be treated with due caution. Table 5 (next page) presents their results on university-industry co-publications (UIC) intensity rankings (UIC as a percentage of total research output) and the percentage of domestic industry partners relative to foreign industry partners.

The authors find that the major research universities in the US and Japan have higher rates of involvement in UIC output from industries within their own countries (80 percent or higher) than do major research universities in other countries. These other universities generally have shares of 60 percent or less. The authors suggest that this may be owing to their relatively smaller number of R&D-intensive companies within these other countries.

[27] There may be differences within and between the two countries with respect to disciplines and sectors. In 2009 the Council of Canadian Academies (CCA) examined a variety of bibliometric indicators in management, business and finance (MBF) disciplines and reported that: "Generally, there is an overall trend of relatively few collaborative research efforts between MBF academics and the private sector, indicating a weak interaction between the producers and the end-users of MBF research in Canada." (CCA, 2009: 31).

Table 5
Top 25 Universities by University-Industry Co-publication (UIC) Output 2002-2006

	University	Country	UIC Intensity (UIC output as percentage of total publication output)	Number of University-Industry co-publications	Percentage UIC involving Domestic Industry Partners
1	Tokyo Institute of Technology	Japan	10	1,006	96
2	Osaka University	Japan	9	1,631	93
3	Hokkaido University	Japan	8	863	95
4	Tohoku University	Japan	8	1,401	93
5	University of Tokyo	Japan	8	2,353	91
6	Nagoya University	Japan	7	761	95
7	Kyoto University	Japan	7	1,473	89
8	Kobenhagen University	Denmark	6	774	60
9	Duke University	USA	6	844	86
10	Seoul National University	Korea	6	850	86
11	Massachusetts Institute of Technology	USA	6	907	78
12	University of California - San Francisco	USA	6	945	88
13	Stanford University	USA	6	1,161	86
14	University of California - Los Angeles	USA	6	1,325	91
15	Imperial College London	UK	5	872	53
16	University of California - San Diego	USA	5	911	85
17	Columbia University	USA	5	945	92
18	University of Washington Seattle	USA	5	1,045	87
19	Johns Hopkins University	USA	5	1,175	87
20	Harvard University	USA	5	2,127	87
21	Cornell University	USA	4	773	86
22	University of Pennsylvania	USA	4	837	86
23	Cambridge University	UK	4	889	61
24	**University of Toronto**	**Canada**	**4**	**924**	**39**
25	University of Michigan Ann Arbor	USA	4	961	85

Source: Tijssen, van Leeuwen and van Wijk (2009). (Data table as originally published has been re-sorted by this author for presentational purposes)

Note: The Tijssen, van Leewen and van Wijk study covers the world's 350 largest research universities measured by publication output in Web of Science-indexed journals during the years 2002-2006. The reported percentage of UIC output involving domestic industry partners may include domestic subsidiaries of foreign companies.

2.5.3 Technology Transfer and Commercialization Indicators

There are many indicators for measuring technology transfer and commercialization performance, including university start-up companies formed, license and royalty income received, and patents disclosed and issued. There are many caveats in using these indicators as proxies for U-B collaboration. While they may measure formal technical exchanges between the two sectors, they are unlikely to represent the extent of informal relationships.

Constructing the indicators themselves is fraught with complexity and challenge both for single countries and even more so with respect to international comparative data. Arundel and Bordoy (2008) provide a very useful overview of data comparability issues across the six main sets of relevant survey data available in the EU, the UK, Australia, the US and Canada. They point out that, apart from comparability issues relating to the survey data itself, a significant challenge for producing internationally comparable indicators is to find a consistent denominator (e.g., research expenditures) to compare outputs across jurisdictions. [28]

Table 6 (next page) summarizes the technology transfer and commercialization indicators as reported for 2004 by Arundel and Bordoy. Canadian data for university patent grants and start-up companies is not reported within Arundel and Bordoy's study and, therefore, the relevant Canadian data has been added based on work undertaken by Clayman (2007). Arundel and Bordoy point out that invention disclosures, patent applications, and patent grants (the top box in Table 6) may represent indicators of commercial potential, while licences executed, start-ups and licence revenues (the bottom box in Table 6) may represent indicators of actual knowledge use.

[28] Arundel and Bordoy point out that: "Another difference in the survey populations that will influence comparability is the proportion of non-university institutes in the respondent samples, which accounts for between zero and 44% of the responses. These differences matter because of variations in performance by type of institution and by country. In the ASTP sample, non-university institutes out-perform universities on patent applications, patent grants, licenses executed and license income. Performance differences by the type of institution were also found in the OECD study (OECD, 2003). In contrast, there is very little difference in the performance of universities and other research institutes in the AUTM sample. One option is to limit the results to universities, but the relevance of this approach depends on the role of non-university institutions in national public research efforts. Only providing results for universities would fail to capture the commercialisation of public science in countries, such as Australia, that invest heavily in government research institutes. To avoid these problems, we provide results for all public science institutes combined and for universities only." (Arundel and Bordoy, 2008: 9-10).

Table 6
2004: Selected Technology Transfer and Commercialization Indicators (Universities). Invention Disclosures, Patent Applicants and Grants, Licenses Executed and University Start-ups per US$ 100 million in University Research Expenditures.

	Canada	US	UK	Australia	EU
Indicators of Commercial Potential					
Invention disclosures	32.0	40.4	51.6	25.4	33.3
Patent Applications	29.7	25.5	15.1	9.5	9.5
Patent grants	4.9[a]	8.8	3.1	8.2	3.8
Indicators of Commerical Application					
Licenses executed	11.3	11.0	36.7	9.5	8.3
Start-ups	1.5[a]	1.1	2.8	0.8	2.8
Licence Income (% of total university research expenditures)	1.0%	2.9%	1.1%	1.7%	1.2%

Source: Arundel and Bordoy (2008) and, for Canadian university patent grants and start-ups, Clayman (2007). Indicators are based on surveys conducted by: the Association of University Technology Managers (AUTM) for the US; the university companies association (UNICO) for the UK (now PraxisUnico); the Australian Commonwealth Government; and the Association of European Science and Technology Transfer Professionals (ASTP Europe) for the EU.

Note (a) Clayman's indicators for Canadian and university patent grants and start-up companies are not strictly comparable to the same indicators for other countries developed by Arundel and Bordoy due to some differences in methodologies employed. For example, Clayman's Canadian data (patents and start-ups) is based on 2004 AUTM survey data for the top 19 (measured by total university research revenues) responding Canadian universities.

Arundel and Bordoy make three descriptive points based on their 2004 indicators, although with numerous caveats due to data comparability issues:

- the US leads by only one indicator, patent grants, while Canada leads by only one indicator, patent applications. Both of these indicators may be taken as representing areas of commercial potential rather than actual knowledge use.

- the UK leads for invention disclosures, licenses executed and, together with Europe, for start-ups. These indicators may be taken as representing areas of actual knowledge use. US and Canadian universities create fewer start-up firms than do universities in the UK and the EU; and,

- The US is the leader when it comes to licence revenues as a percentage of total university research expenditures.

Innovation benchmarking reports from the UK and the EU since 2004 suggest that the broad results reported in Table 6 have not dramatically changed since 2004. The Higher Education Funding Council for England reports that in 2008-2009 UK universities continue to generate more spin-offs but less licencing revenue relative to US universities (HMG, 2010h).

Canadian universities present a mixed picture relative to other jurisdictions. Canada has fewer invention disclosures than the US, the UK and the EU but makes more patent applications. Canada falls behind the UK and the EU in licences executed and start-up companies formed per dollar of research expenditure. But Canadian research-intensive universities appear to be generating roughly the same number of start-up companies per dollar of research expenditure as are US universities.[29]

As discussed in a moment, to the extent the number of start-up companies formed is the most relevant among all these proxy indicator for U-B collaboration, Canadian universities do not appear to be lagging their US or Australian counterparts. To the extent Canadian university start-up rates may be less than their UK (and EU) counterparts, this may reflect the influence of some EU member government incentives for the creation of university start-ups as much as any inherent difference in university behaviour or characteristics.

While all the indicators presented in Table 6 may be of general interest from the viewpoint of measuring (narrowly) technology transfer between universities and businesses, of what relevance are they to the subject of U-B collaboration as the term is used in this report? As suggested in the following discussion, university start-up rates may well be a relevant indicator of U-B collaboration, but indicators based on intellectual property revenues and patenting activity may be more tangential.

University start-ups[30]

Some studies suggest that, far from being an indicator of U-B collaboration, university start-ups are one channel for an "academic brain drain" to the private sector (Czarnitzki and Toole, 2010). Other studies suggest that university-start ups are a "quantitatively" minor part of innovation systems (Cosh et. al., 2006). There are, however, five reasons for considering university start-ups as a relevant indicator of U-B collaboration:

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[29] Clayman (2007) draws on survey data from the Association of University Technology Managers (AUTM) for 1991-2005 and finds that, over much of the period there were some consistent differences between Canadian and U.S. institutions. Canadian universities had less license income received and more start-up companies formed per dollar of university research expenditure in Canada than in the US. This is consistent with Arundel and Bordoy's overall findings for the year 2004. However, Clayman also finds that Canadian university start-up rates were beginning to converge (downward) towards US rates over the 2003-2005 period.

[30] Different studies use different definitions of "university spin-off companies." For the purposes of this report, the term "start-ups" is used here to refer to both university "spin-offs" and "spin-outs" except as other terms are used in cited materials.

- university start-ups may retain formal and informal relationships with their parent institutions for some time after they are created and if for no other reason than their continued geographic proximity to their parent institutions. For instance, Zhang (2009) reports that that more than two-thirds of the university spin-offs in the US that are backed by venture capital are located in the same state as the parent university. In Canada, of the 53 surviving spin-off companies out of a total of 78 spin-offs created since 1972 in the provinces of Manitoba and Saskatchewan, 78 percent remain located in the two provinces (University of Saskatchewan Industry Liaison Office, 2008: 3);

- when universities take an equity stake in university start-ups they may retain it for some time, ensuring at least a continuing legal relationship (subject to various university ethical and financial guidelines[31]) and perhaps too a lasting research relationship;[32]

- continued support from their parent universities is one of the explanatory factors for the longevity of university start-ups relative to other research-intensive and venture-capital backed start-up businesses (Cooper, 2007, and Zhang, 2009) ;[33] Some studies suggest that the availability of, and access to, research infrastructure at universities (and other publicly funded research institutions) is influential in stimulating university-start ups and, although less well documented, may remain important for some time after establishment (Engel and Fier, 2000, Cooper and Barker, 2008, and Colombo et. al, 2010);

- university start-ups can assume greater importance in smaller economies with a limited number of R&D intensive companies and small venture capital markets. The very process of establishing start-ups may bring universities into contact

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[31] For example, at Stanford University in the US, investments in start-up companies in which Stanford faculty have equity interests are subject to the case-by-case approval of the Provost, based upon recommendations by the Chief Executive Officer of the Stanford Management Company (Stanford University, Research Policy Handbook, 2010, Web).

[32] During the 1990s, US universities increased their acquisition of equity stakes in small-firm licensees (Mowery (2009). It is for further research to determine if this finding remains the case today in the US and what Canadian trends may be. In Canada the equity Canadian universities and affiliated teaching hospitals hold in their publicly traded spinoffs declined from C$ 41.3 million in 2005 to C$ 34.8 in 2007 while increasing to C$ 37.8 million in 2008 (GOC, 2010l); Mowery also notes that: "In many cases, university licensing officers believe that equity positions may provide a larger upside potential than a licensing contract alone, especially for a small firm with little if any cash flow. The limited financial resources of start-up licensees also mean that universities may accept equity stakes in lieu of licensing fees or other upfront payments." (Mowery, 2009: 170-171).

[33] Zhang (2009) finds that, apart from their higher survival rates, university start-ups they are not notably different from other venture-capital backed firms along such performance dimensions as: amount of VC money raised, the probability of making a profit, or employment size (see Annex IV for a discussion of government VC instruments and U-B collaboration).

with business and financial systems (especially venture capital) they might not otherwise be exposed to. The intersection of university and business finance systems may itself be important for establishing informal networks for future collaboration between the two sectors (Annex III of this report provides an exploratory review of the intersection of universities and venture capital systems in Canada); and,

- to the extent that university start-ups are not only an indicator of U-B collaboration, but also a driver of U-B collaboration for the reasons set out above, it is relevant to point out that they are susceptible (for better or for worse) to government influence. Cervantes (2004) has noted that university start-ups and licencing activities are, to some extent, substitute activities and that public policy may have an important influence on the choice between start-up and licencing strategies selected by universities. The UK Government's 2003 Lambert report on business-university collaboration expressed the same opinion more forcefully when it said:

> "There is a strong view from both business and universities that in recent years the balance of commercialisation activities has moved too far towards spinouts, driven by the availability of University Challenge Funds and an undue emphasis on the part of Government on spinouts as a source of employment creation." (HMG, 2003a: 50).

Intellectual Property Revenues

University income from intellectual property (IP), including in the form of patent royalties and licensing agreements, is another commonly cited indicator of U-B collaboration. Much of this income is associated with a limited number of patents held by a small number of universities (USG, 2010s). As previously reported (Table 6), licensing revenues account for only a small proportion of total university research expenditures (between 1 and 3 percent) and even less as a proportion of their total revenues (less than 1 percent in Canada, the US, the UK and Australia). In Canada, IP income was C$ 53.2 million for the 125 universities and affiliated teaching hospitals surveyed by Statistics Canada in 2008. Their average income from IP over the past five years has been C$ 55.4 million annually (GOC, 2010t).

Patenting

Academic patenting increased in the US after passage of the *Bayh-Dole Act* in 1980 although some observers believe the stimulative effect of the *Bayh-Dole Act* has declined over time (Leydesdorff and Meyer, 2009).[34] Academic patenting at least

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[34] The *University and Small Business Patent Procedures Act of 1980* (35 U.S.C. 200), commonly known as the *Bayh-Dole Act*, establishes a framework for determining ownership interests in federally funded inventions. Under *Bayh-Dole*, college and university, non-profit, and small business federal contractors may elect to retain title to any invention conceived or reduced to practice in the performance of federally funded research.

initially increased in countries that passed analogous legislation (e.g. Japan in 1999). In general, a mixed picture is presented. The OECD reports that:

> "Between the mid-1990s and early 2000s, the share of patents filed by universities decreased slightly in Australia, Canada, China, Israel, Finland, the Netherlands and the United States. It increased markedly in Japan and the European Union and most notably in Denmark, France, Italy and Ireland, as a direct result of policy changes in these countries in the early 2000s". (OECD, 2009: 25).

Whatever patenting trends may be, it is not clear that a rise in university/academic patenting necessarily represents a rise in U-B collaboration.[35] On this point, a number of commentators (Cosh et. al., 2006, and Dyson, 2010) suggest that access to patents represents a small part of why businesses choose to collaborate with universities. Fini, Lacetera, and Shane (2010) draw on a survey of 11,572 US university academics (representative of the population of 58,646 academics within major US research universities) to find that approximately two-thirds of businesses started by academics are not based on disclosed and patented inventions. Instead, the academics contributed uncodified (e.g. knowledge that is not patented) to the start-ups.[36]

2.5.4 Surveys of National Innovation, Surveys of Business Opinion, and University "League Tables"

U-B collaboration is a subject of attention within various surveys of innovation and business climate conditions. Perhaps because results from these surveys are more "communications-friendly" than other types of indicators, selected results have been cited in a number of government innovation strategies and reports.

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[35] More generally, the Conference Board of Canada has pointed out that: "Classifying innovations into categories of intellectual property offers the seductive practicality of being able to count outputs. Such counting methodology is already in use by the Organization for Economic Co-operation and Development (OECD) and other research organizations that use "number of patents" or "registered trademarks" as proxy measures of country innovativeness. Of course, giving equal weight to all intellectual property units—some of which are less valuable than others— limits the true calibration of innovation and ultimately weakens the correlation between intellectual property outputs and economic productivity. There is not much contribution to economic productivity, for example, in patenting a method for playing with a cat (as has been done.) The next stage of analytic progress on the topic of innovation and economic competitiveness should incorporate attempts to not only count units of intellectual property, but to appraise their economic value as well." (Conference Board of Canada, 2010a: ii).

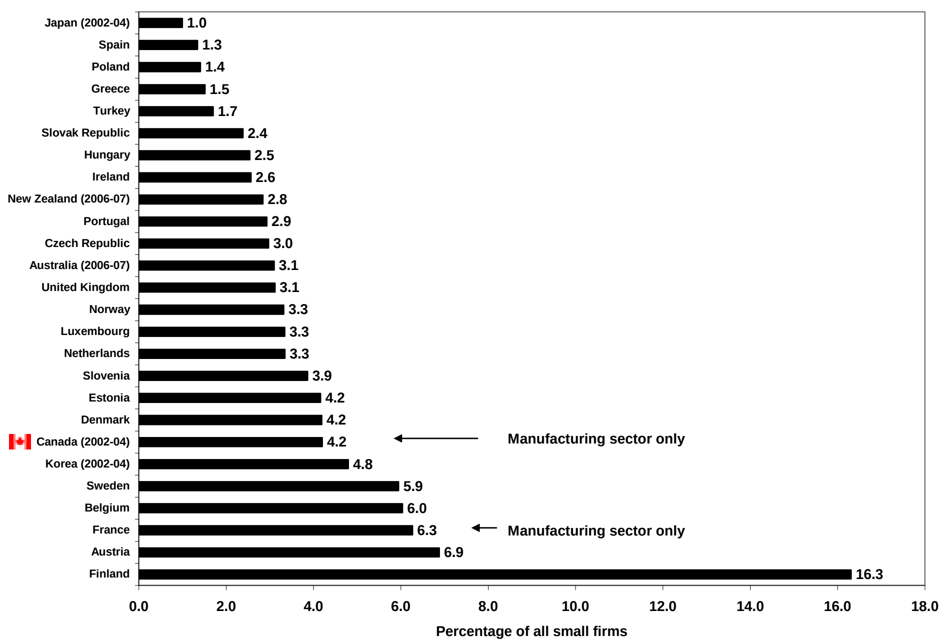
[36] Among the policy implications the authors draw from their findings are: by focusing on patent-based entrepreneurial activity, university administrators (and presumably governments) are ignoring the full potential for entrepreneurial activity present among their faculties; and private sector R&D managers might benefit from developing relationships with researchers rather than interacting with universities solely through their technology transfer offices.

National Innovation Survey Results on U-B Collaboration

The European Union (EU), Australia, Canada and the US conduct national innovation surveys although varying considerably in scope and reference periods.[37] The Canadian 2007 innovation survey and the French component of the most recent EU Community Innovation Survey (CIS) cover only the manufacturing sector.[38] The US innovation survey was introduced in 2009 and with full results to be published in 2011. Every two years the OECD publishes a *Science, Technology and Innovation Scoreboard* in which it reports on U-B collaboration based on innovation survey data from the European Union and other jurisdictions where data is available. Figure 8 (below) and 9 (next page) portrays the OECD data for small and large firms, respectively, collaborating in innovation activities with the higher education sector.

Figure 8

Small Firms Collaborating in Innovation activities with Higher Education Institutions 2004-06 or Latest Year Available (as a percentage of all small firms)



<u>Source</u>: OECD Scoreboard 2007 and 2009. Data for EU countries are from CIS IV 2004-2006.

<u>Notes</u>: SMEs: 10-249 employees for Europe, Australia and Japan; 10-99 for New Zealand; 10-299 for Korea, and 20-249 for Canada.

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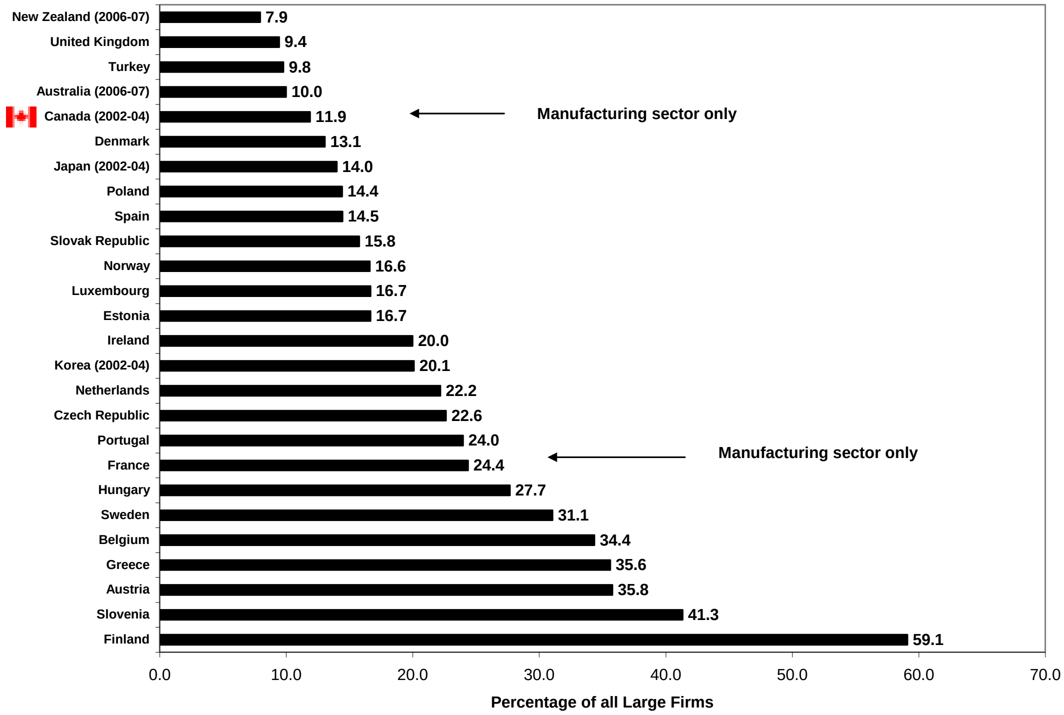
[37] The definition of innovation follows international statistical standards and is defined as a new or significantly improved product (good or service) introduced to the market, or the introduction within an enterprise of a new or significantly improved process. (OECD, 2006: 9).

[38] Statistics Canada will be publishing full results from its 2009 survey of business innovation in 2011.

Figure 9
Large Firms Collaborating in Innovation activities with Higher Education Institutions 2004-06 or Latest Year Available (as a percentage of all large firms)



Source : OECD Scoreboard 2007 and 2009. Data for EU countries from CIS IV 2004-2006.

Notes: Large firms: > 249 employees for European countries, Australia and Japan; >99 for New Zealand; >299 for Korea, and >249 for Canada.

The survey results reported through the OECD Scoreboard support the view that large firms are more likely to collaborate with the higher education sector than are small firms. Beyond this spare fact it is difficult draw any definitive insights from the survey data. For instance:

- the data only indicate the existence of some sort of collaboration, not its type or intensity (OECD, 2009b);

- a higher proportion of companies in Finland are reported to collaborate with universities than in other jurisdictions, but it remains for further research what economic or other circumstances specific to Finland may underpin that fact and what judgment might be made respecting its relevance for other jurisdictions;[39]

[39] For example, it remains for further research why Finland is ranked number one in U-B collaboration in the EU CIS survey results, number three in the World Economic Forum survey results on U-B collaboration for 2010, and yet, according to OECD statistics discussed earlier, Finland ranks: 20th among OECD countries measured by business funded R&D that is performed within the higher education sector and also 20th among OECD countries measured by the portion of all business funded R&D in Finland that is performed within Finland's higher

- low rates for collaboration in Australia may be due to the fact that the EU CIS data refer to any collaboration over a three year reference period while the Australian survey is based on a one year reference period. This difference increases collaboration rates in Europe compared to Australia. (CGOA, 2009g: 39); and,

- national innovation survey data on U-B collaboration may not fully reflect the activities and impact of industry sector bodies and research contract organizations that aggregate large and small firm research activities.[40]

Surveys of Business Opinion

The World Economic Forum's Executive Opinion Survey (WEF-EOS) is another source of information on U-B collaboration citied in some government innovation reports. The wording of the WEF-EOS question on U-B collaboration may have changed slightly over the more than a decade of annual surveys (the scale used to gauge responses has remained unchanged), but the essence of the question remains the same.[41] Since 2008-2009 the WEF-EOS has posed the question: "To what extent do business and universities collaborate on research and development (R&D) in your country? (1 = do not collaborate at all; 7 = collaborate extensively)" (World Economic Forum, 2010: 491).

Table 7 (next page) provides the results for the thirty countries that ranked highest in U-B R&D collaboration in the latest WEF-EOS survey (published in 2010), including their: change in ranking between 2001 and 2010; annual scores; and ten year average scores. The bottom of the table shows changes in ranking over each of the last ten years for Canada, the US, the UK and Australia.

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education sector. Moreover, Finland has 20 universities and 30 polytechnic institutions and it remains to be documented to which of these two higher education sub-sectors the EU CIS U-B collaboration statistics may refer.

[40] Examples of such organizations include: TWI, the UK's global research services company in joining materials and engineering technologies; FPInnovations, a Canadian not-for-profit corporation that mobilizes both large and small firm research funding for forest-related research; SEMATECH, the US-based semiconductor research organization that today is financed primarily by its business members and has built a global research network with equipment and material suppliers, universities, research institutes, start-up companies, and government partners; AMIRA, the mining research organization founded in Australia over fifty years ago and which today serves mining and mineral firms around the world; and clinical research organizations that often enter into formal arrangements with universities for the conduct of clinical trials and other contract research.

[41] Prior to 2008-2009, the WEF Executive Opinion Survey asked: "In the area of R&D, collaboration between the business community and local universities is (1 = minimal or nonexistent, 7 = intensive and ongoing)."

Table 7
World Economic Forum Executive Opinion Survey on U-B R&D collaboration. (1= do not collaborate at all; 7= collaborate extensively) Top 30 countries 2001-2010

Rank 2001	Rank 2010	Country	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	10 Yr. Avg.
7	**1**	**United States**	**5.3**	**5.6**	**5.4**	**5.4**	**5.7**	**5.5**	**5.6**	**5.8**	**5.9**	**5.8**	**5.6**
8	2	Switzerland	5.3	4.9	4.7	5.0	5.1	5.7	5.6	5.6	5.7	5.7	5.3
1	3	Finland	6.1	5.9	5.9	5.8	5.4	5.5	5.5	5.5	5.6	5.6	5.7
17	**4**	**United Kingdom**	**4.9**	**4.9**	**4.9**	**5.0**	**5.0**	**4.9**	**5.0**	**5.1**	**5.4**	**5.6**	**5.1**
2	5	Sweden	5.7	5.4	5.3	5.3	5.0	5.5	5.6	5.6	5.6	5.5	5.5
3	6	Singapore	5.6	5.0	5.3	5.1	5.0	5.2	5.3	5.5	5.6	5.4	5.3
6	**7**	**Canada**	**5.3**	**4.9**	**5.0**	**4.7**	**4.7**	**4.8**	**4.9**	**5.0**	**5.2**	**5.4**	**5.0**
16	8	Denmark	5.0	4.6	4.6	4.8	4.9	4.7	5.0	5.3	5.5	5.3	5.0
12	9	Germany	5.1	5.1	5.1	5.2	5.1	5.3	5.3	5.4	5.2	5.2	5.2
5	10	Belgium	5.4	5.2	4.6	4.5	4.6	4.9	5.1	5.2	5.3	5.2	5.0
9	11	Netherlands	5.2	4.8	4.4	4.9	4.6	4.9	5.0	5.1	5.2	5.2	4.9
15	12	Taiwan, China	5.1	5.2	5.0	5.1	4.9	5.2	5.1	5.1	5.1	5.2	5.1
14	**13**	**Australia**	**5.1**	**4.4**	**4.2**	**4.3**	**4.1**	**4.1**	**4.4**	**4.8**	**4.9**	**5.1**	**4.5**
4	14	Israel	5.5	5.6	4.8	4.8	4.7	5.2	5.2	4.8	4.6	5.1	5.0
x	15	Luxembourg	x	x	2.9	3.0	2.7	3.5	3.6	3.9	4.7	5.1	3.7
18	16	Iceland	4.9	4.3	4.6	4.3	4.4	4.5	4.7	5.0	4.8	5.0	4.7
11	17	Ireland	5.1	5.2	4.7	4.3	4.3	4.6	4.8	4.9	5.0	5.0	4.8
13	18	Austria	5.1	4.6	4.1	4.6	4.4	4.6	4.8	5.0	4.9	4.9	4.7
26	19	Japan	4.4	4.1	4.5	5.0	4.6	5.2	4.9	4.6	4.7	4.9	4.7
21	20	Norway	4.6	4.1	4.3	4.2	4.2	4.6	4.8	4.9	4.9	4.9	4.6
25	21	New Zealand	4.4	4.1	4.0	4.0	4.1	4.2	4.4	4.3	4.7	4.8	4.3
42	22	Malaysia	3.6	3.8	4.0	4.6	4.7	4.9	4.9	4.8	4.6	4.7	4.5
20	23	Korea, Republic of	4.6	4.3	4.3	4.2	4.8	4.6	5.4	5.1	4.6	4.7	4.7
23	24	South Africa	4.6	4.3	4.2	4.3	4.2	4.3	4.2	4.2	4.5	4.6	4.3
28	25	China	4.2	4.5	4.2	4.2	3.9	3.9	4.1	4.5	4.6	4.6	4.3
24	26	Hong Kong SAR	4.6	3.6	4.1	4.4	4.1	4.6	4.6	4.5	4.4	4.6	4.4
x	27	Qatar	x	x	x	x	2.6	3.1	3.5	4.2	4.0	4.5	3.7
41	28	Costa Rica	3.7	3.6	3.1	3.1	3.4	3.5	3.7	3.9	4.3	4.4	3.7
32	29	Czech Republic	4.1	4.1	3.7	3.8	3.9	4.0	4.1	4.2	4.4	4.5	4.1
37	30	Portugal	3.8	3.4	3.3	3.3	3.5	3.7	3.6	3.6	4.1	4.5	3.7
10	*44*	*France*	*5.1*	*3.8*	*4.2*	*4.0*	*4.5*	*3.8*	*3.9*	*3.9*	*3.9*	*4.0*	*4.1*
38	*58*	*India*	*3.7*	*3.4*	*3.2*	*3.6*	*3.3*	*3.6*	*3.5*	*3.6*	*3.8*	*3.7*	*3.5*
Mean score for all countries in in survey including top 30			**3.9**	**3.6**	**3.3**	**3.3**	**3.1**	**3.3**	**3.3**	**3.4**	**3.6**	**3.7**	**3.5**
Number of countries included In WEF survey by year			**75**	**80**	**102**	**104**	**117**	**125**	**131**	**134**	**133**	**139**	

WEF position ranking by year	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**10 Yr. Avg.**
Canada	**6**	**12**	**7**	**13**	**13**	**14**	**15**	**14**	**9**	**7**	***11***
United States	7	2	2	2	1	4	1	1	1	1	*2*
United Kingdom	17	10	8	8	7	10	12	9	7	4	*9*
Australia	14	17	22	18	23	25	22	19	14	13	*19*

Source: Compiled by the author from the World Economic Forum, *Global Competitiveness Report* annual editions.

Note: X = country not reported in the annual *Global Competitiveness Report.*

The results from the WEF-EOS over the past ten years (and keeping in mind that the number of countries included in the survey has expanded from 75 countries in 2001 to 139 countries in 2010) show that:

- eight countries in the top 10 in 2001 remained in the top 10 in 2010: the US, Finland, Sweden, Germany, Singapore, Belgium, Switzerland and Canada;

- there has been movement in and out of the top 10 rankings over the past decade. The UK and Denmark moved up into the top ten ranking by 2010. They have replaced Israel and the Netherlands who ranked in the top 10 in 2001;

- over the past decade, the highest average scores (on a scale of 1-7) in U-B R&D collaboration have been (Finland (5.7); the US (5.6); Sweden (5.5); Switzerland (5.3); Singapore (5.3); Germany (5.2); Taiwan; (5.1) the UK (5.1); Israel (5.0); Belgium (5.0) and Canada (5.0); and,

- some countries have significantly declined in the overall rankings. For example, France ranked 10th in 2001 but ranked 44th in 2010. India ranked 38th in 2001 but ranked 58th in 2010.

The Institute for Management Development (IMD) also conducts an annual business opinion survey and asks business executives (from 58 countries in its 2010 survey) whether "knowledge transfer" between companies and universities is "highly developed" or "lacking" in their countries. Consistent with the WEF-EOS results, the IMD survey results over the past three years assign Canada an increasing rank: rising from 10th position in 2008 and 2009 to 8th position in 2010. On the other hand, the IMD and WEF-EOF rankings over recent years are not consistent when it comes to some other countries (e.g., the UK ranks 15th in the IMD 2010 survey results while it ranks 4th in the 2010-2011 WEF-EOS results).

The OECD Scoreboard statistics on U-B collaboration and the World Economic Forum survey results have found their way into at least two major government reports on national S&T and innovation performance. The Commonwealth Government of Australia's 2009 innovation strategy, *Powering Ideas*, states:

> "Australia's innovation system is handicapped by fragmentation, duplication and a lack of coordination. Business-to-business and research-to-business links are poor. We rank last in the OECD on rates of collaboration between firms and universities… Australia's connections to global research and business networks are also inadequate, and our distance from the knowledge-intensive economies of the northern hemisphere is still a problem, even in the digital age." (CGOA, 2009*l*: 59).

The Government of Canada's Science, Technology and Innovation Council reported in 2009:

> "A number of studies suggest distinct aspects of university–business linkages. R&D cross funding between the Canadian business sector and universities is high by international standards, both as a share of total Canadian research and as a share of GDP. However, the proportion of Canadian businesses collaborating with universities on R&D is low by international standards. The state of university–business R&D collaboration in Canada was not ranked highly by the World Economic Forum Competitiveness Survey. Since there is strong evidence that businesses can benefit from research and innovation collaboration with universities, it is important to understand why these various sources give apparently conflicting conclusions on the state of inter-sectoral collaboration in Canada (GOC, 2009*l*: 7).

Canada's Science, Technology and Innovation Council's observation that the World Economic Forum's survey results assigned a low ranking for Canada was based on the WEF-EOS data available at the time (2008 and prior year results). As has been mentioned, Canada has moved up in the ranking to 9th place in 2009-2010 and to 7th place in 2010-2011.

University League Tables

In September 2010 the Times Higher Education World University Rankings (co-authored by Thomson Reuters) were published and received considerable media attention.[42] Canadian media reports highlighted that the methodology underlying the 2010 rankings scaled back the weight attached to the importance of reputation and included a new "knowledge transfer" indicator (Beck and Morrow, 2010: 1). But on closer examination, the Times Higher Education 2010 university league rankings are a poor guide to "knowledge exchange" activities of universities. They are based partly on an "indicator category" of "Industry income — innovation." Yet this is not just a category. According to Phil Baty, Deputy Editor of the rankings, it actually represents a single indicator, "a simple figure giving an institution's research income from industry scaled against the number of academic staff." Moreover, as Baty states:

> "We plan to supplement this category with additional indicators in the coming years, but at the moment we feel that this is the best available proxy for high-quality knowledge transfer. It suggests the extent to which users are prepared to pay for research and a university's ability to attract funding in the commercial marketplace — which are significant indicators of quality. However, because the figures provided by institutions for this indicator were patchy, we have given the category a relatively low weighting for the 2010-11 tables: it is worth just 2.5 per cent of the overall ranking score." (Baty, 2010: Web).

The word "patchy" is the right word to use. Among the top 100 ranked institutions, 39 failed to provide any data on industry income to the compilers of the rankings. For institutions that did report data, it will be important to take account of what they

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[42] Three Canadian universities were ranked in the top 50 universities and six more in the top 200 world-wide.

reported and consistency in reporting (e.g., contract research income, consulting income, IP revenues, and in-kind contributions).

2.5.5 The Contribution of U-B Collaboration to Productivity

The theoretical and empirical research on the relationship between innovation (broadly defined or more narrowly conceived) and productivity is extensive and the general conclusion is not surprising: the creation, diffusion, and application of knowledge is positively correlated with productivity growth and levels both for individual firms and economy-wide. This provides much room for conjecture on what specific contributions U-B research may make to productivity for individual firms or economy-wide, but the empirical evidence base for measuring that contribution is still being built. Nonetheless, studies undertaken on U-B collaboration as a determinant of productivity for individual firms and the academic sector are interesting. For example:

- Motohashi (2004) has found a positive association between U-B collaboration and R&D productivity (using patenting as a proxy) with respect to younger and technologically based firms in Japan. This finding is of public policy interest when it sits beside other indicators suggesting the SMEs may be less likely to engage in UB collaborations than larger firms; and,

- Abramo, D'Angelo, Di Costa and Solazzi (2009) investigate whether university collaboration with domestic companies is related to the scientific performance of universities. The authors conduct a regression analysis on bibliometric data from 78 universities in Italy and find that university researchers who collaborate with those in the private sector show research performance that is superior to that of colleagues who are not involved in such collaboration. Zinner et. al., (2009), in their study of academic-industry relationships in the US life sciences sector, conclude that: "On all measures, faculty with industry relationships published significantly more and published at a greater rate in the past three years than respondents without such connections." Other studies in this area are more circumspect. For example, Banal-Estanol et. al. (2008) find that while academic researchers with industrial links publish significantly more than their peers, academic productivity (measured by publication output) is higher for low levels of industry involvement as compared to high levels.

Yet it remains that U-B collaboration has not been definitively linked to increased productivity performance at the firm or economy-wide levels. Of course, a wide range of government support programs for business R&D are based on the belief (supported by empirical research) that: social rates of return on research are considerably larger that private rates of return (Scott et. al., 2002, and US National Academies of Sciences, 2005); and that businesses tend to under-invest in R&D because they are unable to fully appropriate all the benefits for themselves. However, it is only by inference that business R&D conducted in collaboration with universities can be said to generate social returns that exceed private returns. This is an important area for future conceptual and empirical research.

2.6 Summary Findings

Definition

In this report U-B collaboration is defined as the set of relationships established by the two sectors to advance their different interests and objectives. This definition and perspective removes any illusion (that may be inspired by the very use of the word "collaboration") that the two parties are somehow removed from the real world of negotiating in their own self-interest. Looking at U-B collaboration as a negotiation – in research but perhaps too in other areas of engagement – casts a new and different light on the role of government. From this perspective, a central role government can play is creating conditions for successful negotiations between the two parties. It is also one policy lens for considering the effectiveness (or otherwise) of government measures to encourage U-B collaboration.

Motivations

Universities and businesses have different motivations for collaborating. Businesses place access to highly qualified people, the development of their future labour force through the education of students, and access to university researchers and facilities, at or near the top of their motivations for collaboration. Perhaps obviously, businesses look to universities for access to knowledge and talent to strengthen their competitiveness. Universities have diverse and diffuse institutional motivations for collaborating with business (e.g. diversifying their research funding sources or as an element of their branding strategies). The motivations of individual academics for collaborating with businesses are various, but generally do not include seeking immediate personal financial gain – at least in the short run.

Barriers

Many surveys and studies on barriers to U-B collaboration have been undertaken. The problem with results from this work is that they may wrongly be taken to suggest that policies targeted at the removal of any particular barrier will generate an immediate "increase" or "improvement" in U-B collaboration. Ross Finnie, Associate Professor at the University of Ottawa's Graduate School of Public and International Affairs, has suggested that when a given area of public policy interest is defined by a high degree of uncertainty and complexity, then a narrow barrier-removal strategy may not always yield desired outcomes. [43]

Several surveys find that businesses do not rank increasing their profitability at the top of their list of motivations for collaborating with universities. This is deserving of further research to better understand, given that other surveys find that businesses

[43] Finnie made this observation in the context of a presentation to a CSLS seminar on the subject of access to post-secondary (PSE) education. He suggested that policies intended to raise post-second education participation rates overall need to go beyond barrier-oriented policy tools and strategies such as those related to student financial aid and tuition fees.

perceive the "long term orientation" of university research as a significant barrier to collaboration. As an initial proposition, this report suggests that business concerns over the long-term orientation of university research may not only be misplaced but may run counter to the self-interest of both business management and shareholders.

Among the most interesting of empirical research findings on barriers to U-B collaboration is that firms and universities seem to learn by doing, including overcoming orientation barriers and, to a lesser extent, transaction barriers (e.g. IP management processes and research funding arrangements). In essence, U-B collaboration may be regarded as being as much a "stock" as a "flow" phenomenon. Additions to the stock of U-B collaboration may exhibit considerable longevity rather than being transitory in time.

Determinants

Business determinants for entering into research collaborations with universities have been the subject of extensive research. The main findings include:

- **Large firms are more likely to collaborate with universities than are small firms.** However, there is good reason for policy makers to focus on encouraging collaboration between smaller firms and universities. Firm size has generally not been found to be a robust predictor for innovation. In fact, while large firms do spend more on R&D than smaller firms, due to their size and greater profits, they may not be intrinsically more innovative. Indeed, small firms are found be more innovative per dollar of R&D.

- **U-B collaboration is more likely to occur in some economic sectors than others.** The extent of U-B collaboration within any jurisdiction reflects the research intensity of different economic sectors. Cross-national differences in U-B collaboration may reflect differences in the structure of national economies.

- **Reports on the death of the linear model of innovation, where universities push out inventions and knowledge which are then commercialized by businesses, have been exaggerated**. The linear model implies there is a one way flow of knowledge: universities are the location for basic research which is then translated through applied research to commercialization and application in the marketplace. This linear model has fallen out of favour over recent decades. Other perspectives on innovation have been advanced, including those based on "ecosystem" and network models of innovation processes. Yet linear models remain prominent within government policy statements. It is likely that the most effective public policies to improve business innovation and encourage U-B collaboration in the future will draw insight from both traditional and new ways of thinking about innovation;

- **Firms tend to collaborate with universities that are nearest to them.** One empirical study suggests that, in Canada, as the geographic distance between a business enterprise and a university increases by ten percent, the fraction of the total R&D expenditures of that enterprise directed to that university decreases by just over one percent. Proximity matters to U-B collaboration, but this is not inconsistent with survey and research findings on how multinational corporations decide on where to allocate their R&D resources. They take the presence of, and access to, local universities into full account in making their R&D investment decisions.

- **Firms that receive government subsidies and incentives for R&D are more likely to collaborate with universities than those that do not.** However, this may be because of the industry and university participation conditions attached to government support programs or, alternatively, because firms that collaborate with universities are just more likely to be recipients of government support. In the specific area of government R&D tax credits, little is known about their incremental impact on encouraging U-B research collaboration. This has not stopped many stakeholder groups from advocating R&D tax credits that are designed to encourage U-B collaboration.

Measurement

Measuring U-B collaboration relies on a fairly narrow range of indicators: research funding; bibliometric; technology transfer; and indicators derived from various surveys of innovation and business opinion. In summary:

- **Funding Indicators.** Large Canadian government investments in research performed in the Canadian higher education sector do not appear to have markedly “leveraged out private sector funding” for research performed in the higher education sector. Canadian business funding of HERD has flatlined over the past decade in constant dollar terms and as share of total HERD. Canadian business funding of HERD in an international context suggests that Canada is leading many other jurisdictions (including the US, the UK and Australia). But there are many reasons, and not only reasons relating to weaknesses in the international comparability of the data, for why Canada cannot take any large degree of comfort: Canada may have an underachieving denominator (Business Expenditures on Research and Development or BERD) rather than an overachieving numerator (BERD performed in the higher education sector); and a small number of projects undertaken by a small number of large companies may heavily influence both annual data and longer term trends;

- **Bibliometric Indicators.** The number of university-industry co-authored (UIC) science and technology publications is increasing internationally, in part driven by increasing UIC publication rates in China. Canadian UIC publications increased between1980 and through to 2005 to reach the rates achieved in the US in 2008;

- **Technology Transfer and Commercialization Indicators.** These indicators are challenging to construct, are subject to wide interpretation and, in any case, their relevance as proxy indicators of U-B collaboration (as opposed to technology transfer activity levels) is open to debate. Based on 2004 data assembled by one group of experts, the US leads the UK and some other EU countries by indicators of commercial potential (e.g., patent applications and patent grants per dollar of research expenditure), while universities within the UK and some other EU countries lead by indicators of commercial application (e.g. licence executed and university start-up companies formed per dollar of research expenditure). US universities appear to lead all jurisdictions considered by licence revenues received as a percentage of total university research revenues.

  Canadian universities present a mixed picture relative to other jurisdictions. With respect to indicators of commercial potential, Canada has fewer invention disclosures than the US, the UK and the EU but makes more patent applications. With respect to indicators of commercial application, Canada falls behind the UK and the EU in licences executed and start-up companies formed per dollar of research expenditure. But Canadian research-intensive universities appear to be generating roughly the same number of start-up companies per dollar of research expenditure as are US universities. To the extent Canadian university start-up rates may be less than their EU counterparts, and although a subject for future research, this may reflect the influence of EU government incentives for the creation of university start-ups as much as any inherent difference in university behaviour or characteristics.

There are various surveys on business opinion on the strength of linkages between universities and business. Canada has moved up in the rankings for U-B research collaboration within the World Economic Forum's Executive Opinion survey results over the past decade. It has moved from 9th place position to 7th place over the last two years. The IMD survey of executive opinion has also assigned Canada an increasing rank over the past three years, rising from 10th place position in 2008 to 8th place position in 2010.

U-B Collaboration and Productivity

Although the empirical research base is still being built, U-B collaboration appears to make a positive contribution to: firm-level productivity performance (although one can always find individual cases where this may not be so); possibly also to academic research productivity; and, if only by implication, to economy-wide productivity performance (although by how much, even if it were measurable, is completely unknown).

Taken together, these summary findings help set the context for considering how Canadian federal and provincial governments are encouraging U-B collaboration. Before doing so, however, it is useful to set out a descriptive framework for assembling and reporting on policy measures to encourage U-B collaboration.

3.0 A FRAMEWORK FOR DESCRIBING POLICY MEASURES TO ENCOURAGE U-B COLLABORATION

3.1 The Descriptive Framework

This report adopts a four part framework to organize and present information on policy measures to encourage U-B collaboration that individually exhibit great diversity in design and implementation. The framework reflects theories on the choice of governing instruments (e.g., Lowi, 1972; Doern and Wilson, 1974; Trebilcock and Hartle, 1982; and Trebilcock, 2005). It builds on and expands work undertaken by Harmon (2005). It sets out four roles for government: as advocate, enabler, funder and rule-maker.

Government as advocate

This function is exercised through:

- issuing policy statements and strategies that indicate the priority accorded by government to U-B collaboration and that often set out government markers for what forms of U-B collaboration (and in what areas) will be funded or otherwise supported;

- commissioning or supporting studies on U-B collaboration (sometimes accompanied by consultation exercises with the general public or stakeholder groups) or using such other instruments and channels of persuasion as sponsorship of events and conferences;

- revising mandates of existing government institutions or making other changes in the machinery of government to encourage them to focus on U-B collaboration. Such changes may carry important symbolic as well as substantive meaning; and,

- measuring and publicly reporting on U-B collaboration and issuing various public recognition awards for U-B collaboration.

Government as enabler

This function is exercised through:

- supporting or permitting an expanding range of activities by intermediary organizations (or creating new ones) to encourage U-B collaboration. Such organizations (sometimes referred to as “border-spanning institutions” and “Fourth Pillar organizations”) are diverse in form, function, and scale of activity. Nonetheless, at their core they often serve as negotiating forums where different university and business (and often government) objectives and interests can be identified and reconciled to find mutually beneficial (or, at a minimum, mutually acceptable) outcomes;

- drawing on government physical and intellectual research assets, such as co-location of government research facilities with those of businesses and universities and sometimes accompanied by unified management structures; and,

- supporting institutions and processes for the exchange of labour market information between the two sectors and also programs to facilitate researcher and employee mobility between the two sectors.

Government as funder

This function is exercised through:

- attaching conditions to research funding for universities or for individual researchers that require, explicitly or implicitly, involvement of business sector partners;

- funding nationally and internationally significant collaborative research projects where government, university and industry participation is the fundamental operating assumption;

- targeting economic development programs and associated funding to geographically defined “clusters” of university and business activity;

- aligning fiscal incentives (e.g., R&D tax credits) to support U-B research collaboration; and,

- leveraging other spending instruments (e.g. government procurement) to encourage U-B collaboration.

Government as rule-maker

This function is exercised through:

- regulatory regimes for intellectual property;

- the design and implementation of other regulations (e.g., in the areas of antitrust, export controls, immigration, the regulation of product standards, the regulation of foreign investment, and the conduct of research itself); and,

- direct or indirect influence over university governance and management arrangements.

Two of these four categories, government as enabler and government as rule-maker, are deserving of extended explanation.

Government as enabler

To describe government as an enabler can connote a role for government that is: indirect rather than direct; limited rather than expansive; and supportive rather than coercive. [44] Of course, the design and outcome of enabling measures may result in a government role this is all or none of these.

This report separates out government support measures for intermediary organizations from other types of enabling measures. This is because intermediary organizations play a prominent role in regional and national innovation systems. Metcalfe (2010) suggests that while firms can manage to innovate entirely through their own internal efforts, access to external knowledge often requires that the firm develop (or rely on) innovation intermediaries to complement their internal arrangements. There are hundreds of organizations that may be characterized as performing intermediary functions to enable innovation (Dalziel, 2010). The intermediary organizations selected for inclusion in this report:

- focus their activities and resources on the university and business relationship although very typically this encompasses the other (government) dimension of the "triple helix" of university-business-government relationships;

- received start-up funding from government and, in some cases, continue to receive government funding to support their operations and activities; and,

- serve to illustrate that governments are supporting two types of intermediary organizations:

    - those with a sectoral focus (on technological fields or industry sectors) and that often reflect national R&D investment policy priorities; and,

    - those without any pre-defined technology or industry focus and that often reflect more general policy objectives (e.g. buttressing the professional, financial or other capacities of universities and businesses – most often small and medium sized businesses – to engage with one another).

[44] For example, the UK Coalition Government's Agreement (2010) states that: "For years, politicians could argue that because they held all the information, they needed more power. But today, technological innovation has – with astonishing speed – developed the opportunity to spread information and decentralize power in a way we have never seen before. So we will extend transparency to every area of public life. Similarly, there has been the assumption that central government can only change people's behaviour through rules and regulations. Our government will be a much smarter one, shunning the bureaucratic levers of the past and finding intelligent ways to encourage, support and enable people to make better choices for themselves." (HMG, 2010p: 7-8).

Government as rule-maker

The role of government as "rule-maker" encompasses the use of regulatory policy instruments but may also involve a variety of "informal" rule making activities including: administrative guidelines; formal or informal agreements; requiring undertakings under legislative authority; and direct or indirect influence on the structure and management of universities. There are two features of government rule-making activities to encourage U-B collaboration that distinguishes them from the much larger universe of government rule-making activity:

- they are intended to achieve any number of broader policy objectives, but encouraging U-B collaboration is one of their *foreseen* consequences; and,

- they may have a diffuse impact on U-B collaboration but nonetheless have a significant and *foreseen* influence on economic and other incentives for U-B collaboration.

3.2 Applying the Framework

There are three introductory points respecting the application of this framework within this report:

- the framework does not address to full satisfaction various policy instrument "boundary" problems. Not all policy measures cited have encouraging U-B collaboration as their primary objective (although many do), but all have encouraging U-B collaboration as an important sub-objective or are premised upon U-B collaboration. Some measures may have multiple characteristics (e.g., advocacy, enabling, funding and rule-making). A degree of qualitative judgment is exercised in both identifying and positioning policy measures in this report;

- many of the examples provided are central government policy measures. However, sub-central government levels (and the national Administrations of Scotland, Wales and Northern Ireland through devolution) have constitutional responsibilities for education, including higher education. The examples of sub-central government measures presented at least suggest the U-B collaboration is of policy interest across all levels of government; and,

- this report follows in the path taken by two recent high-level reviews of tertiary education across national jurisdictions (OECD, 2009c and UNESCO, 2009) and does not provide a definition of a university. Universities may be defined according to various legal, institutional (i.e., university association membership), administrative, and statistical collection criteria and purposes. Nonetheless, both the OECD and UNESCO reports highlight an increasing diversification of institutions in both form and function for the provision of higher education. The UNESCO report emphasizes the expansion of different types of institutions with different functions. In contrast, the OECD report draws attention to a growing diversity of educational offerings within single institutions, regardless of their type. The OECD report states:

> "For instance, traditional universities are increasingly expanding their educational offerings to include short-cycle courses and more vocationally-oriented degrees. This trend reflects that, in some countries, distinctions between institutional types have become blurred. In some of these, university systems have become formally "unitary". For instance, binary university systems were abolished in Australia and the United Kingdom in the late 1980s and early 1990s respectively." (OECD, 2009c: 23).

Each of the following sections of this report, one each for Canada, the US, the UK and Australia, opens with a synopsis of the subject country's university system followed by a description of the historical evolution of government policies to encourage U-B collaboration. The examples of public policy measures are then presented according to the framework of government as advocate, enabler, funder and rule-maker.

4.0 Canada

1.1 Context

The Association of Universities and Colleges of Canada (AUCC) has 94 member institutions and represents all the major Canadian universities. In 2008-2009 total enrollment at Canadian universities was 1.1 million persons: 796 thousand full time and 270 thousand part-time. The Association of Canadian Community Colleges (ACCC) has 150 member institutions and represents the majority of colleges, institutes of technology, cégeps (les collèges d'enseignement général et professionnel), and polytechnics in Canada. The ACCC estimates that full and part-time enrollment in its member institutions has approached 1.1 million over recent years.[45]

Canada no longer has a high level and permanent national forum that brings together industry and university leaders. In 1983 the Canadian Corporate-Higher Education Forum (C-HEF) was established to bring the leadership of major Canadian businesses into contact with university leadership. C-HEF has been inactive since 2000. The forum was an initiative of Concordia University, which agreed to house its secretariat until 1997 at which time it was moved to the University of Calgary. Over the course of its existence through to 2000, C-HEF was chaired a series of prominent individuals, including: Lloyd Barber (former president of the AUCC), James Downy (former president of three Canadian universities and later president and CEO of the Higher Education Quality Council of Ontario); and John H. Dinsmore (former Deputy Minister with the Government of Québec and today a member of the Osborne Group). C-HEF's last chairman (between 1996 and 2000) was Norman Wagner, former President of the University of Calgary (1978-1988). C-HEF's founding corporate members included senior executives from such companies as Bombardier, Imperial Oil and Bell Canada.[46]

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[45] This report focusses on public policies to encourage collaboration between business and universities rather than with vocationally-oriented colleges. However, the relationships between business and vocational education institutions, and the role of public policy in strengthening those relationships, are a subject deserving of further research. As pointed out by the ACCC: "Over the last three years, there has been a dramatic increase in the number of companies partnering with colleges for applied research projects and colleges are now extensively involved in regional and national research networks. …Colleges are key instruments for helping the federal government meet the goal of increasing business investment in research and development, in particular by SMEs. SMEs are at the heart of Canada's competitiveness and productivity, and the principal source of job creation. ACCC has recommended that the Government of Canada review its research investments from the perspective of SMEs with a view to balancing investments in discovery research with increased support for the practical side of research that helps businesses start, develop and grow and thus improve productivity and competitiveness." (Association of Canadian Community Colleges, 2010: 24).

[46] C-HEF began to fade-away by 2000, possibly because of generational change in university and business leadership or perhaps because it failed to deliver value to its members.

In 2006, total public and private expenditures of tertiary education in Canada were 2.6 percent of GDP. In comparison, and for the most recent years for which data is available, total public and private expenditures on tertiary education as a percentage of GDP are: 1.5 percent in Australia; 1.3 percent in the UK; 3.1 percent in the US, and an average of 1.5 percent across all OECD countries (OECD, 2010).

The Canadian constitution assigns responsibility for education, including higher education (described in Canada as post-secondary education), to the thirteen provincial and territorial governments.[47] The federal government contributes indirectly to funding the operational costs of higher education through transfer payments to provincial and territorial governments. In 2010-2011, the federal government will transfer C$ 3.4 billion for post-secondary education to provincial and territorial governments. The federal government also provides student loans and a variety of tax-based supports.

The federal government funds research at Canadian universities through a variety of programs, including those operated through three federal granting councils (the Natural Science and Engineering Research Council, the Social Sciences and Humanities Research Council and the Canadian Institutes of Health Research). Federal funding is also provided for research infrastructure through the Canada Foundation for Innovation and for research professorships through the Canada Research Chairs program. A separate federal funding program exists to help cover the institutional ("indirect") costs of research. Vocational education in Canada, generally delivered through the college system, has come to be an area of shared responsibility between federal and provincial governments (Lyons et. al., 1991).

Canadian federal government research organizations underwent considerable expansion during and after the Second World War. Figure 10 (next page) illustrates the evolution of selected aspects of the federal government's institutional and policy architecture for innovation.

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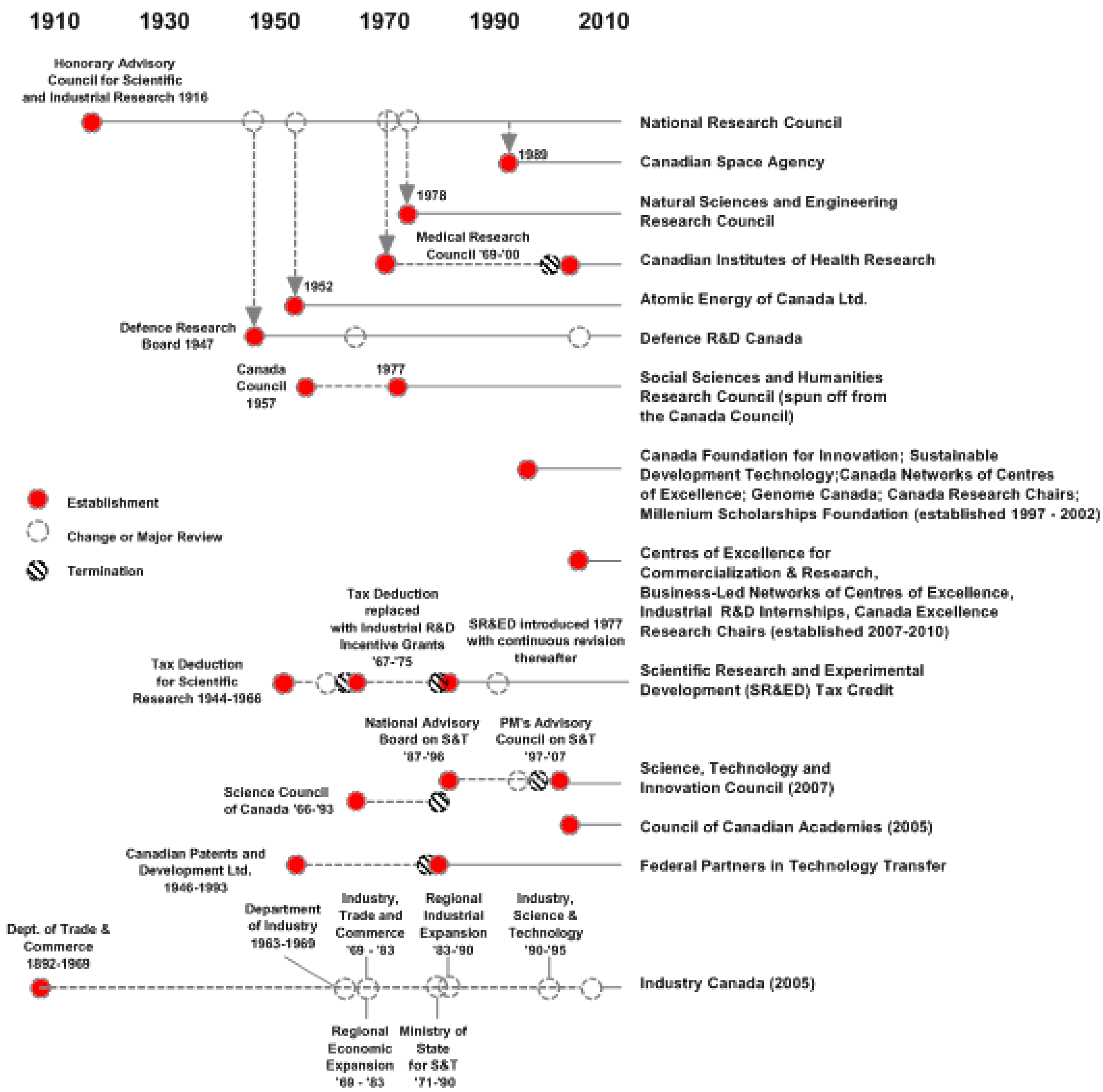
[47] The Canadian federal government has constitutional and treaty obligations for education for First Nations peoples on reserves.

Figure 10
Selected Aspects of the Evolution of Federal Architecture for Research and Innovation (illustrative not comprehensive)



Source: Developed by the author based on a presentational idea from Cutler (2008).

Note: The federal government operates 198 laboratories and other science facilities across Canada (GOC, 2008b).

Concern with U-B collaboration was not prominent at federal and provincial government levels until the early 1980s, although there was a continuing evolution of public policy thinking about the relationship between the university and business sectors over the post-1945 period. Four policy signposts marking this evolution were:

- **Report of the Royal Commission on Canada's Economic Prospects (Gordon, 1957)**. The Royal Commission was launched by the federal government led by Prime Minister Louis St. Laurent in 1955 and was chaired by Walter Gordon (who later became Minister of Finance under Prime Minister Lester Pearson). The Commission's report recognized an important role for universities in the training of scientists and researchers but the relationship between universities and business did not draw their extended comment except through indirect reference:

  > "Lack of balance, with neglect of fundamental research, results when universities must rely on funds which are provided for specific and applied purposes. Fundamental research can only be given its proper emphasis when available funds can be used to this end. It may not be possible to define precisely the volume of fundamental research which should be undertaken in Canadian universities, but we feel it necessary to warn against a tendency to subordinate fundamental to applied research, and to point out that as our universities grow the proper performance of their functions will require increasing support for research of a fundamental nature."(GOC, 1957: 455).

- **A Science Policy for Canada (Lamontagne, 1970-1977).** In 1967 the Canadian Senate adopted a resolution setting up a special committee to review science policy in Canada. Chaired by Senator Maurice Lamontagne, the Committee issued four reports between 1970 and 1977.[48] The Committee's 1972 report, *Targets and Strategies for the Seventies*, found that Canadian business R&D expenditures on R&D as a share of total R&D expenditures were among the lowest in the OECD and government research institutions accounted for the largest portion of national R&D expenditures. The report found this was a "logical outcome of the embedded model" where government research institutions conducted applied research, including through Canada's National Research Council.[49] The report

[48] The Lamontagne committee was mandated to examine: trends in R&D expenditures over time; R&D activities by the federal government; federal assistance to various groups to support R&D; and broad principals, financial requirements, and the structural organization required for a dynamic and efficient science policy. It issued three main reports: "A Critical Review: Past and Present" (1970); "Targets and Strategies for the Seventies" (1972); and "A Government Organization for the Seventies"(1973). The Commission issued a follow-up report on "Progress and Unfinished Business" in 1977. The work of the Lamontagne Committee had been preceded by a 1963 Royal Commission on Government Organization (Glassco) which had called attention to the lack of a national science policy.

[49] The report examined an array of other explanatory factors, including levels of foreign ownership and control and the high tariff regime for much of the manufacturing sector (although

recommended that federal support for university research grants and support for national laboratories should be institutionally separated (a recommendation that subsequently led to the establishment of Canada's three research granting councils).

The Commissioners found that relationships between universities and business were not as strong as they might be. They recommended that a study of future skills requirements be undertaken and that a national conference of industry and university representatives be held to consider mechanisms for cooperation between the two sectors. The Commissioners envisioned a role for government in strengthening linkages between the university and business sectors but not a continuing role:

> "In addition to the proposed study, we believe that more permanent steps should be taken to bridge the gap between the academic and industrial sectors. These two worlds must always be different because their missions are not the same. However, they are becoming more and more interdependent. Universities could not survive and expand without industry and, as the scientific and technological era develops, industry needs universities. The fact that in the past they have contrived to exist separately and cultivate a mutual contempt is no justification for maintaining the two solitudes in the future. What is required is an effort to build institutional links that will develop not only a continuing dialogue but concrete co-operation. But even here, patterns should not be imposed from the outside. This responsibility should be left to the two sectors. However, participatory democracy often needs an initial spark to begin to work, especially when it involves groups that have seldom had an opportunity to meet and start talking. We feel that Canadian universities and industry should be given this opportunity."(GOC, 1972: 521).

- **1981 Annual Statement of the Chairman of the Science Council of Canada (Fortier, 1981).** A different perspective on U-B collaboration, and the role of government in encouraging such collaboration, was set out by Claude Fortier, the Chairman of the Science Council of Canada (a federal government advisory body established by federal statute in 1966 and which existed until 1993) in 1981. He opened his 1981 *Annual Statement*,[50] which he devoted entirely to "University-Industry Interaction", by observing:

> "Growing public interest in the interaction between universities and industry can be attributed to the current shortage of university-trained manpower in many engineering and scientific disciplines, increasing

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not in the automotive sector where Canada had entered into a bilateral free trade agreement with the US through the Canada-US Automotive Products Trade Agreement of 1965).

[50] Fortier's 1981 Annual Statement is contained as an insert within the Science Council of Canada's 1981 Annual Report.

> public awareness of the scientific and technological implications of providing Canada with the energy it requires, and the belief that much of the lack of competitiveness of Canadian industry can be attributed to its low level of research and development."

Fortier went on to say that "prior to the explosive expansion of our universities in the late 1950s and 1960s, university-industry interaction was left largely to the bodies concerned" and that:

> "There was a general absence of pressure to encourage interaction, either through formal regulations or generously funded government programs. Government had not yet entered the picture to change the relatively simple two-body nature of university-industry relations into a three-body system, in which there are now three interfaces to be dealt with, instead of one."

Much of Fortier's statement was devoted to advocating federal-provincial mechanisms and programs to "assist the universities in providing the operation manpower so essential to the health of the Canadian economy." He took note of the range of existing U-B institutions for research collaboration, including the Industrial Research Institutes located at Canadian universities and which had received start-up funding from the federal government's Department of Industry, Trade and Commerce starting in the late 1960s. But this particular model for encouraging U-B collaboration did not appear to attract his strong support:

> "They [the Industrial Research Institutes] were established through negotiations between the university and the department, not in response to a need expressed by industry, but to act as brokers to sell the services of individual faculty members to industry in the form of contracts."

- **Task Force on Federal Policies and Programs for Technology Development (Wright, 1984).** By the mid-1980s the Canadian federal government had come more firmly to the view that U-B collaboration was a matter of public interest. The signpost report was issued in 1984 by a task force set up by the federal government and chaired by Douglas Wright (President and Vice-Chancellor of the University of Waterloo between 1981 and 1993). The main challenge for the task force was to recommend how to bring coherence to the multitude of federal regional economic development programs that had grown up over time and shift federal industrial policies and strategies away from the provision of subsidies to industry. (Doern and Levesque, 2002).

  One of the report's chapters was devoted entirely to "university-industry cooperation" and opens with the statement: "If university laboratories were ever "ivory towers", they are emphatically less so today. Universities now play a central and strategic role in Canada's overall research effort." (GOC, 1984: 19). The report called attention to the model of federal support for university research represented by the Natural Science and Engineering Research Council (NSERC -

which, in 1978, had assumed the research granting functions of Canada's National Research Council in natural sciences and engineering disciplines):

> "Of all the Canadian agencies, programs and projects we encountered in the course of our research, NSERC was the most widely praised. We believe it must continue to play an important and expanding role in the development of Canada's scientific potential. The principles under which it operates, and which are to some degree responsible for its success, should be applied more widely: industry participation, peer review and a minimum of bureaucratic complexity."(GOC, 1984: 20).

The Wright report warned against creating a plethora of programs aimed at encouraging this or that aspect of industry-university co-operation and recommended, instead, that a flat 25 percent bonus of the actual value of cooperative work carried out by universities for the private sector should be paid to the universities by the federal government. The report also argued in favour of using the tax system to incent U-B collaboration: "If companies could earn a 50 percent tax credit for R&D that was performed on their behalf by universities, it would dramatically stimulate the desired dialogue between industry and universities." (GOC, 1984: 19).

- **Royal Commission on the Economic Union and Development Prospects for Canada (1985).** The royal commission was established in 1982 and was chaired by the Honourable Donald S. Macdonald. It recommended that Canada should negotiate a free trade agreement with the US. Among its other recommendations for future growth and employment, the Commissioners said: "Post-Secondary institutes should place more emphasis on science, engineering and business courses. Universities should be more active in the commercialization of inventions." The Commissioners also took note of the emergence and role of intermediary organizations sitting between business and universities: "Technology brokers, contract-research organizations and think-tanks have assisted technology acquisition in other countries. Both the private and public sectors in Canada should consider more activity of this nature." (GOC, 1985: VII, 383).

The increasing federal and provincial government interest in encouraging U-B collaboration during the 1980s and thereafter took place within the changing global economic and technological circumstances of the time and was influenced by domestic circumstances, including:

- **the integration of the Canadian and US economies (accelerated by the negotiation of the 1988 Canada-US Free Trade Agreement (FTA)).** This placed new competitive pressures on Canadian businesses and new constraints on how governments could assist their businesses through subsidies and other support mechanisms. This was a supporting circumstance for greater government interest in measures to support business competitiveness in ways that were FTA compliant, including a first generation of policies (such as the federal Networks of Centres of Excellence program established in 1989) to strengthen what was increasingly referred to as a national innovation system within a "knowledge-based economy";

- **fiscal constraints on Canadian governments.** These constraints were felt through the 1980s and culminated in the so-called "northern peso" crisis in the early 1990s. The policy priority placed on reigning in government deficits at federal and provincial government levels was reflected in wide-spread spending restraints, including federal and provincial funding for higher education (Martin, 2009). This led universities to seek to diversify funding sources, most importantly through seeking increases in tuition fees, but also through their engagement with the business community; and,

- **a volatile constitutional context.** This context was marked by the 1980 Government of Québec's provincial referendum on a proposal for sovereignty-association with Canada (which was rejected by Québec voters); the 1982 *Constitution Act* (which passed despite the Government of Québec's objections); the 1987 Meech Lake Constitutional Accord (which failed to achieve the required ratification by all provincial governments); the 1992 Charlottetown Constitutional Accord (which failed to achieve the required support in a national referendum); and the Government of Québec's 1995 provincial referendum on sovereignty ("after having made a formal offer to Canada for a new economic and political partnership") and which failed by a narrow margin. These were defining political circumstances for federal government support for higher education during the 1980s and after. Through to mid-1990s the federal government treaded with caution in its support for the higher education sector. It continued to do so after the 1995 referendum and yet a larger political space for federal government involvement in specific areas emerged (i.e. research funding, encouraging U-B collaboration in research areas, and funding for vocational training on the basis on federal-provincial labour market agreements).

4.2 Canadian Governments as Advocates

The examples of U-B advocacy through policy statements and strategies (and associated commissioned reports) in this section are organized by level of government. Canadian federal governments of different political stripes have advocated greater U-B collaboration primarily under the rubric of strengthening the Canadian "innovation system" – a term which reflected the increasingly dominant way of thinking about science and technology policy during the late 1980s and through to today.[51] Canadian

[51] Over the past thirty years, innovation as a source of economic growth and social advantage has been increasingly viewed in all OECD countries from a structuralist perspective, where "innovation systems" are a prime focus of attention. Innovation systems are generally considered to be that set of distinct institutions which jointly and individually contribute to the development and diffusion of new technologies (Metcalfe, 1995). This perspective became the dominant way of thinking about S&T policy for a variety of reasons, perhaps not the least of which is the room

provincial governments frequently highlight U-B collaboration as one element of their broader innovation policies and strategies although they are not as forceful advocates of U-B collaboration within their higher education policy statements and reports. Canadian local governments have also been advocates for U-B collaboration within their communities, with the strongest local government advocates being those who have invested in their local research parks and business incubator facilities located on or adjacent to their local university and college campuses.

4.2.1 Federal Government Statements and Strategies

- **A New Framework for Economic Policy and Building a More Innovative Economy (1994).** These two federal policy documents, the first issued by the Minister of Finance and the second by the Minister of Industry, set out a macro and micro economic growth agenda. Both papers highlighted the need to strengthen linkages between academia and industry. The Finance paper said:

> "Although Canadian academic scientists and engineers are among the world's best in many fields, there has been far too little success translating good research ideas into commercial success. Canadian medical researchers, for example, are at the leading edge in several fields but the commercial 'receptor capacity' to develop their ideas scarcely exists in this country. This is unfortunately all too typical. Developing linkages that really work between Canada's knowledge base and its commercial base will therefore remain an ongoing challenge and priority." (GOC,1994: 66).

  Both papers deferred to a then forthcoming federal review of S&T policies with respect to the specific measures that would be taken.

- **Federal S&T Policy Review (1994-1996).** This review involved: an internal government review; a public consultation process; and an external review by the National Advisory Board on Science and Technology (NABST). The review was linked to the larger program of spending cuts the federal government was embarking on through what was known as Program Review (Cruikshank and Holbrook, 2001). The final NABST report, *Healthy, Wealthy and Wise: A Framework for an Integrated Federal Science and Technology Strategy*, emphasized the need for collaboration and multidisciplinary research throughout the innovation system. It recommended that the federal government should encourage collaboration between large companies, SMEs, universities and colleges. (GOC, 1995). The S&T review led to the federal policy document *Science and Technology for the New Century: A Federal Strategy*. The strategy advocated the building of partnerships, alliances, networks and other linkages between "innovation system" participants (GOC, 1996).

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it provides for governments of all political stripes to intervene under the banner of strengthening relationships between innovation system components.

- **Federal Government Innovation Strategy Development and Statements (1997-2002).** Starting in 1997, the federal government began a large program of investments in university research and research capacity, including: the Canada Research Chairs program to attract the world's best and brightest researchers to Canadian universities; the Canada Foundation for Innovation to fund research infrastructure; the Indirect Costs of Research Program (initially funded in 2001 and made permanent in 2003); Genome Canada to support large-scale genomics and proteomics research projects; further funding for the Networks of Centres of Excellence (originally established in 1989); and increased funding for Canada's granting councils (including the Canadian Institutes for Health Research established by the federal government in 2000 and which replaced the Medical Research Council of Canada). Federal funding for university research through these programs and instruments grew from some C$ 733 million in 1997-1998 to almost C$1.7 billion in 2001-2002. Funding continued to flow through the same instruments to reach a C$ 2.9 billion in 2007-2008 (AUCC, 2008a: 14).

  Yet it was after many of these investments had been announced that, in February of 2002, Prime Minister Jean Chrétien announced that Canada was developing a new innovation strategy and that:

  > "To stimulate reflection and to help crystallize a Canada-wide effort, we are releasing two papers: *Knowledge Matters: Skills and Learning for Canadians* and *Achieving Excellence: Investing in People, Knowledge and Opportunity*. From this starting point, we look forward to building a broad consensus not only on common national goals, but also on what we need to do to achieve them in the Canadian way." (GOC, 2002c: 2).

  The *Achieving Excellence* paper stated that: "The government is committed to bringing university researchers together with firms to ensure that our best ideas make it to the marketplace." (GOC, 2002a). The implicit message of both papers (and the subsequent national consultation process and national summit held in 2002) was that the federal government had done its part and now it was time for business and other sectors (including universities) to step up to the plate.

- **Report of the Expert Panel on the Commercialization of Research (2006).** This report resulted from the work of a six-member expert panel chaired by Joseph L. Rotman, Canadian businessman and philanthropist. The government asked the panel to: "provide advice on how the federal government can proceed with an integrated strategy to bring about the fundamental changes required to improve Canada's commercialization performance over the long term." (GOC, 2006c: 2). The core of the report's eleven recommendations, delivered to a new minority government led by Prime Minister Stephen Harper, was "a new role for the private sector as a full partner in charting the course for, and developing policy related to, commercialization." The main finding of the report made the implicit message of the 2002 *Achieving Excellence* paper explicit: Canada faced a demand rather than supply-side challenge. The Expert Panel said:

> "Canada has come a long way in addressing the supply side of the commercialization equation. It has increased funding for university research that produces both the knowledge and the talented people needed for commercialization, and it has employed tax measures to attract risk capital. But there is a broad range of evidence that Canada is still struggling on the demand side — in the pull from the private sector." (GOC, 2006b: 2).

- **Advantage Canada – Building a Strong Economy for Canadians (2006).** The federal government's Minister of Finance, the Honourable Jim Flaherty, issued this broad economic policy statement in the fall of 2006. The statement included reference to encouraging U-B collaboration but was quite careful in describing the role of the federal government:

  > "Introducing research networks managed and led by the private sector and focused on addressing the practical needs of businesses will create more value from business-university collaboration. As there may be insufficient economic incentives for the private sector alone to support this type of partnership, there may be a limited role for government support. The Government can also help businesses, including small and medium-sized enterprises, become more innovative by accessing the technology development and application capacity residing in community colleges." (GOC, 2006: 66-67).

- **Mobilizing Science and Technology to Canada's Advantage (2007).** This federal government S&T strategy set out four principles for action: promoting world-class excellence; focusing on priorities, enhancing accountability; and encouraging partnerships. (GOC, 2007b: 11). The S&T strategy reported on a variety of measures the government was taking to encourage partnerships, including between universities and business. It also said "more can be done" although leaving it unclear as to by whom:

  > "Efforts to support the transfer of technology from Canadian universities to the private sector are resulting in spin-off companies, technology licensing agreements, and patent filings. More can be done to encourage technology transfer at both ends of that process. A review will be launched to uncover factors that might be inhibiting S&T collaboration between industry and the higher-education sector (universities and colleges). This review will include an assessment of whether a new approach to intellectual property management of university research is warranted. In the meantime, the government will pilot laboratory technology transfer; greater involvement by the private sector in the design of these new approaches is needed." (GOC, 2007b: 57).[52]

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[52] The review of factors that might be inhibiting S&T collaboration between industry and the higher education sector will form part of the review of federal government support for business and commercially relevant R&D announced March 2010 federal budget.

- **Compete to Win (2008).** In July of 2007 the federal Minister of Finance and the federal Minister of Industry jointly announced the establishment of a five member Competition Policy Review Panel chaired by Mr. Lynton Ronald (Red) Wilson, former President and Chief Executive Officer of Bell Canada Enterprises. The panel's core mandate was to review the *Competition Act* and the *Investment Canada Act*. While many of the panel's recommendations related to its core mandate, it also advanced a larger "competitiveness agenda" embracing a wide array of policy areas and issues. For example, the Panel said that:

  > "…post-secondary education institutions must collaborate more closely with the business community. The model of the academy being withdrawn from the economy is outdated. Business–university collaboration is key to Canada's ability to be more competitive in the future. Business leaders can contribute to the governance, direction and financing of educational institutions. Close collaboration will help ensure that universities better prepare their graduates to capitalize on opportunities in the private sector by tailoring their programs to labour market needs. It is in Canada's best interest for programs taught on our campuses to be better aligned with our economic objectives." (GOC, 2008: 67).

- **Expert Panel for Review of Federal Support to Research and Development (appointed October 2010).[53]** This expert panel is mandated to consider and provide recommendations on: what federal initiatives are most effective in increasing business R&D and facilitating commercially relevant R&D partnerships; is the current mix and design of tax incentives and direct support for business R&D and business-focussed R&D appropriate; and what, if any, gaps are evident in the current suite of programming, and what might be done to fill the gaps? The panel issued a public consultation paper issued in December 2010 and invites public comments a variety of questions, including:

  > "Regarding networks, collaborations and linkages, what are the main impediments to successful business-university or business-college

[53] The Expert Panel is chaired by Mr. P. Thomas Jenkins, Executive Chairman and Chief Strategy Officer of Open Text Corporation, a major Canadian software company (in 2008, Mr. Jenkins has also served as a member of the federal government's Competition Policy Review panel). The other panel member are: Mr. Dr. Bev Dahlby, a professor of economics at the University of Alberta; Dr. Arvind Gupta, professor of Computing Science at the University of British Columbia and is CEO and Scientific Director of Director of the Mathematics of Information Technology & Complex Systems group (MITACS); Mrs. Monique F. Leroux, Chair of the Board, President and Chief Executive Officer of Desjardins Group, the largest financial cooperative group in Canada; Dr. David Naylor, President of the University of Toronto; and Mrs. Nobina Robinson Chief Executive Officer of Polytechnics Canada, a national alliance of the leading research-intensive, publicly funded colleges and institutes of technology. The Panel is expected to issue its report before the end of 2011.

> partnerships? Does the postsecondary education system have the right capacity, approaches, and policies for effective partnerships with business?" (GOC, 2010q: 13).

4.2.2 Provincial Government Statements and Strategies

Each of Canada's provincial and territorial governments has published an "innovation strategy" over the past decade and many contain strong reference to U-B collaboration as critical to improving innovation performance. Three examples are:

- **The Government of Québec's Research and Innovation Strategy (2010).** This strategy sets a 2013 target of achieving a 10 percent increase in the number of collaborations between universities and businesses above the annual average of "6 000 collaborative projects observed over the past three years." The strategy includes such initiatives as: financial assistance to university researchers to devote themselves to this research training in an industrial context; support for proof of concept centres and university development corporations; the introduction of incubation vouchers to enable businesses to draw on the services of technology incubators; and financial support for technology transfer organizations (Government of Québec, 2010: 7).

- **The Government of British Columbia's Research and Innovation Strategy (2007).** This strategy sets out six objectives, one of which is to: "Strengthen collaboration between industry and academia in key sectors, here and around the world." Monitoring the strategy's implementation has been left to the BC Premier's Technology Council (PTC). During 2010, the PTC conducted a public consultation (online) on the subject of commercialization of university research and, in its June 2010 annual report to the Premier, highlighted five themes and issues that it intends to address in its next annual report:

> "Culture Shift – Institutions need to garner a better understanding of industry needs and priorities.
>
> Partnerships – There needs to be greater trust between the commercialisation parties; academia views the industry as unscrupulous and industry too often views the universities as a provider of service rather than a partner.
>
> IP Policy – Industry participants believed IP Policy was too complicated and cumbersome. There was also some discussion around whether IP Policy should be more standardised across the board, or whether it should be more flexible to adjust to each individual case.
>
> Success Measures – Revenue to the institution should not play a role in measuring the success of commercialisation. Measures that should be

considered are those of economics (company growth, revenue growth, sectoral growth and overall economic growth) or those that measure the creation and transfer of Highly Qualified Personnel (HQP), who are viewed as IP carriers.

Role of Government – Government was seen either as an entity that can promote the partnership necessary for commercialisation, or as an entity that can financially support commercialisation through incentives and subsidies to promote commercialisation or tax credits (like SR&ED) or other benefits to promote research." (Government of British Columbia, 2010: 4).

- **The Government of Ontario's Innovation Agenda (2008).** This strategy sets out a "catalytic role" for the provincial government to facilitate interaction between researchers, ideas and the market: "In this role, Ontario's government supports close partnerships between industry and academic research teams as an important way to support the innovation system, create new knowledge and harvest its benefits." (Government of Ontario, 2008: 9).

Canada's provincial government statements and commissioned reports on their higher education sectors often advocate U-B collaboration as a means to advance the performance (usually in research areas) of their universities. However, a less strident tone is adopted compared with their treatment of U-B collaboration within their innovation policy statements and reports. Six examples are:

- **The Government of Nova Scotia's** September 2010 *Report on the University System in Nova Scotia* recommends that the provincial government should:

  - Encourage universities to explore private ownership and management opportunities for some of their facilities.

  - Encourage more research, technology transfer, and commercialization, under the following guidelines:

    a. Create an effective mechanism for harnessing the potential of applied research currently being conducted by university faculty.

    b. Before renewing major funding directed at encouraging research commercialization, carry out a comprehensive assessment of the effectiveness of such funding.

    c. Consider maintaining the Industry Liaison and Innovation (ILI) office at Dalhousie, and amalgamating the industrial liaison offices of other universities into one. (Government of Nova Scotia: 2010b).

- **The Government of British Columbia's** 2007 report on its higher education system, *Campus2020 – Thinking Ahead,* included the recommendation that the provincial government should: "Establish a continuing commercialization strategy to ensure that the province and post-secondary institutions are maximizing opportunities to benefit from commercially realizable research discoveries." (Government of British Columbia, 2007: 81). However, the report was cautious on what might be achieved: "Public investment is crucially important, particularly in BC. Private sector investment has a role to play, but in Canada that investment is particularly influenced by the concentration of major industries in Ontario and Québec. As a result, levels of private sector investment in research and development in BC are relatively low, and are likely to remain that way." (Government of British Columbia, 2007: 79).

- **The Government of Saskatchewan's** October 2007 *Post-Secondary Education Accessibility and Affordability Review* (delivered to the government just one month prior to its election defeat) recommended that the province: "Develop an analysis of research and innovation expenditures in Saskatchewan and identify additional resource needs to facilitate commercialization of research and better link research to industry." (Government of Saskatchewan, 2008: 14).

- **The Government of Newfoundland and Labrador's** 2005 *White Paper on Public Post-Secondary Education* states that: "Our post-secondary institutions are actively engaged in building productive partnerships with business and labour. They recognize that good links play an important role in tackling problems resulting from low skill levels, which constrain our productivity and our economy." (Government of Newfoundland and Labrador, 2005: 11).

- **The Government of Ontario's** report on its higher education sector, *Ontario a Leader in Learning* (2005), and the report of the **Government of New Brunswick's** Commission on Higher Education, *Advantage New Brunswick* (2007), make only minor reference to U-B research collaboration. The Ontario report, authored by the Honourable Bob Rae, in one of its very few references to the commercialization of university research, said that:

  > "There has been considerable discussion, both at the federal and provincial levels, about the need to encourage the commercialization of research. This is important, but it must be borne in mind that basic research remains fundamental to the mission of higher education. If the universities don't pursue it, it is hard to know who will. Nobel Prize winner John Polanyi has often pointed out that it is the breakthroughs in basic science that eventually find their way to commercial use. These breakthroughs may not be immediately apparent but their long-term impacts are profound." (Government of Ontario, 2005: 10).[54]

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[54] In 2005 the Government of Ontario issued a five-year and C$ 6.2 billion framework policy for higher education, *Reaching Higher,* that focused on making higher education more accessible and

4.2.3 Local Government Statements and Strategies

Many Canadian local government economic development strategies recognize their universities and colleges as assets for attracting new business investment through their contribution to strengthening local labour markets. Local governments who are the strongest advocates for U-B collaboration (as defined in this report) are also those who support (financially and otherwise) research and science parks on or adjacent to the campuses of their local colleges and universities or who are vigorously pursuing "creative economy" strategies.[55] Three of many examples are:

- **The City of Montreal's** *2025 Imaginer > Réaliser* strategy highlights the city's creative economy and its attraction for U-B research collaborations. The Mayor of Montréal, Gérald Tremblay, told the Manhattan Chamber of Commerce in September 2010 that:

  > "…at least 180 cities around the world see themselves as creative communities. How then can we stand out? Well, our particular brand of creativity stresses collaboration. For the past twenty years, I have been a steadfast proponent of collaboration between firms, academia, unions, public bodies, and civil society, within industry-specific clusters, as Michael Porter originally defined them. Now, we need to foster more collaboration across industries and disciplines." (Tremblay, 2010: 3)

- **The City of Calgary's** Economic Development Strategy (2008) states that the city will: "Develop Innovation Park, one of Canada's largest concentrated advanced technology campus' located at the University of Calgary, for collaborative industry and institutional research, and attract all research associated with local companies to this development, providing green space for technology commercialization and company creation."(City of Calgary, 2008: 48)

- **The City of Kingston's** Economic Development Corporation (KEDCO) 2010-2015 business plan states that: "The attraction of new businesses and people to Kingston is critical to the city's growth and sustainability. With a focus on green technologies, research and innovation, KEDCO will

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affordable. Support for university-based research was largely left to a new Ministry of Research and Innovation created in 2005 and also to a new not-for-profit delivery organization, OCE Inc., established to deliver of programs to encourage U-B research collaboration (see section 4.3.1.2 of this report). In March 2010, the Government of Ontario announced a new economic strategy, *Open Ontario*, that includes a commitment to: "work with all its partners in education, training and business to develop a new, five-year plan to improve the quality of Ontario's postsecondary education system." (Government of Ontario, 2010)

[55] The Canadian Association of University Research Parks reports that here are between 20 and 30 research and science parks in cities across Canada.

> aggressively market Kingston's strong and diversified economy as a safe place to invest with an exceptional geographic location, proximity to major markets, a highly skilled and knowledgeable labour force, linkages to three premium research focused educational institutions, a vibrant quality of life with excellent tourism-based services and the developing incubation space at Innovation Park." (City of Kingston, 2010: 1).

The capacity of local governments to be advocates for, and enablers of, U-B collaboration within their communities is sometimes tied by municipal leaders to their broader concerns respecting intergovernmental financing issues. The Big City Mayors' Caucus policy statement of 2006, *Our Cities, Our Future,* ties the development of local "creative economies", including U-B collaboration, to progress on better matching the revenues of municipal government with their responsibilities.

4.2.4 Measuring and Reporting on U-B Collaboration

Advocacy in any area of public policy is strengthened by a strong evidence base and the capacity to draw on and effectively communicate that evidence. Over the past decade, the federal government and a number of provincial governments have reported extensively on innovation performance within their jurisdictions, but their reporting on U-B collaboration is at an early stage of development at the federal level and is even more limited at provincial and municipal government levels.

The federal government's Science, Technology and Innovation Council's 2009 *State of the Nation* report on S&T included indicators of U-B collaboration and stated that that there is limited understanding of the dynamics of collaboration, either between firms or between firms and public research institutions, including universities:

> "Our data allow us to count the number of collaborations by companies or public research institutions, but we know very little about the kinds of collaboration being done. We also do not know which collaborations have been successful and which have not, whether collaborations differ by industry, or the extent to which these collaborations involve only domestic companies or are global in nature. Many of the same challenges exist for international patent data, which is why data on patents have not been included in this report." (GOC, 2009*l*: 3).

The Council considered the contrast between the high level of business funding of R&D in Canadian universities and the survey results on U-B collaboration in Canada (those available to it at the time of their work) was puzzling and called for further investigation:

> "While businesses spent a relatively high proportion of their R&D dollars in universities, the OECD placed Canada near the bottom of OECD countries in terms of the proportion of businesses collaborating with universities for R&D. In the World Economic Forum's survey of executives, a relatively low share of Canadian executives gave positive reviews of the state of university–business

> cooperation in Canada. These different findings suggest that a more in-depth look is needed, not only at the numbers of companies collaborating with universities, but also looking at companies' own perceptions of that collaboration."(GOC, 2009*l*: 36).

Provincial and territorial governments do not report regularly or comprehensively on U-B collaboration within their jurisdictions. Municipal governments (and their economic development agencies and corporations) do not report systematically on U-B collaboration. The two major indexes of community well being in Canada (The Community Foundations of Canada's Vital Signs initiative and that issued by the Community Index of Well Being (CIW) Network) do not include a U-B collaboration component.

4.2.5 Other Advocacy Activities

Federal and provincial governments have engaged in other U-B advocacy activities, including: changes to the "machinery of government" which can have important symbolic as well as substantive meaning; and sponsoring various public recognition award programs.

A number of provincial governments have made machinery of government changes for a diverse range of purposes. From a U-B advocacy perspective, these changes serve to reinforce U-B collaboration as a priority within their innovation strategies. For instance, on October 25th, 2010, BC Premier Gordon Campbell (who just one week later announced that he would step down as Provincial Premier) announced that a new Ministry of Science and Universities would be created. BC universities formerly came under the Ministry of Advanced Education and Labour Market Development. Other examples include: Alberta's creation of a new Alberta Innovates – Technology Future organization (2009); Québec's merging of existing research financing organizations into a single new organization, the Fonds Recherche Québec (Québec Research Fund) (2010); and Ontario's creation of a Ministry of Research and Innovation in 2005 which centralized a range of pre-existing and new programs for encouraging U-B research collaboration and commercialization of results (Sa, 2010).

There are also instances of federal and provincial governments advocating U-B research collaboration through various public recognition award program. Beginning in 1995, the federal Natural Sciences and Engineering Research Council has recognized effective U-B research collaborations through its "Synergy Awards for Innovation." The Government of Ontario's Centres of Excellence (OCE Inc.) honours the best OCE-supported and commercially successful collaboration between university, college, and industry partners through its annual "Mind to Market Award". The Alberta Science and Technology Foundation (ASTech - created with the support of the Government of Alberta) honours outstanding achievement in applied technology and commercialization achievement.

4.3 Canadian Governments as Enablers

4.3.1 Support for Intermediary Organizations

Canadian federal and provincial governments support many intermediary organizations whose mandates include encouraging U-B research collaboration.[56] Examples of these organizations are presented in this section in two categories:

- **Sectoral organizations.** There are at least 25 Canadian organizations that have U-B intermediation as their core activity and have a clear sectoral focus.[57] They have active participation from a defined base of business members and relevant university departments. Although in many cases they are conduits for government funding of research, in general they do not conduct research themselves (although a number lease office and laboratory space to researchers).

- **Horizontal organizations**. These organizations (which include Canada's regional network organizations for the commercialization of university research) generally do not define themselves by any specific technology or sectoral interest.

The examples of these organizations provided below are not organized by level of government given the considerable and notable extent of joint federal-provincial support.

4.3.1.1 Sectoral Organizations

The sectoral organizations with U-B intermediation as a core activity take on various legal forms, although most often they are constituted as not-for-profit corporations. Almost without exception, they have received start-up funding from governments and, in the majority of cases, continue to receive government funding. Eight examples of both older and more recent sectoral organizations are presented below. Two of the

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[56] The federal government has also provided support for organizations whose mandate is to enable transfer of technology from *government* research facilities to the market. Examples include: the Canadian Patents and Development Ltd., a crown corporation which existed between 1948 and 1993; and, more recently, the Federal Partners in Technology Transfer (FITT) organization (a "community of practice" of federal public servants).

[57] The Canadian Association of Business Incubation has compiled an inventory of 102 business incubators in Canada (CABI, 2010). However, not all business incubators necessarily are concerned with U-B collaboration as the term is used in this report. The federal government's Invest in Canada Bureau's (within the Department of Foreign Affairs and International Trade) inventory of 250 "research and testing centres"(excluding government laboratories and NRC facilities) are another source of information to identify sectoral intermediary organizations. The majority of these 250 research and testing centres are located on or adjacent to university campuses. Many of the centres are primarily concerned with research, but a limited number are more concerned with managing and facilitating research conducted by others.

organizations described below also received funds through the federal government's C$ 285 million Centres of Excellence for Commercialization and Research (CECR) program (see section 4.4.1.2 of this report).

Pre-Competitive Advanced Research Network (Precarn Inc.)

Precarn was incorporated in 1987 as a non-profit corporation for the commercial development of robotics and intelligent systems through U-B research collaboration. It is worthwhile highlighting the circumstances surrounding Precarn's creation. They call attention to the role of serendipity and the vision of individual university and business leaders in shaping institutions to encourage U-B research collaboration in Canada.

Precarn is a child of the Canadian Institute for Advanced Research (originally called CIAR but today known as CIFAR). CIAR was established at the University of Toronto in the late 1970s to encourage and support "research that broke new ground in concept, in the relations between disciplines and administrative units within the university and between the university and the larger community."[58] In his history of CIFAR, the eminent Canadian historian Robert Craig Brown (2007) has described how CIAR's first president, Dr. Fraser Mustard, and William Tatton, a CIAR research fellow, established an Artificial Intelligence, Robotics and Society (AIRS) research program in 1983. The program was supported by a C$ 250,000 annual contribution over three years from Spar Aerospace. Spar also provided two of its company researchers to help conduct research for a set period of time. Over the following five years, the Artificial Intelligence and Robotics (AIR) program (the "and society" element was dropped) received considerable corporate support from a range of iconic Canadian companies, including Petro-Canada, Lumonics, MacDonald Dettwiler and Dofasco.

Brown records that, by 1986, it became apparent that the AIR program was not going to be the way to achieve the kind of interaction of scientists with industrial engineers that was important to the program's industrial supporters and affiliated industrial researchers. Brown writes that:

> "The problem was highlighted at a Vancouver meeting in January 1986. It had been called to stimulate strong interaction between the AIR group and industrial researchers. John Tsotsos from the [AIR] Toronto node, who had had considerable experience of his own trying to work with industrial firms, told Mustard that he and his university colleagues came away from the meeting aware of several 'mismatches.' 'The qualities that make a good [university researcher],' he wrote, 'generally speaking, make one a poor choice for industrial interaction…. More than once, an industrial attendee claimed that universities should not be engaged in "sterile research", or should find out what industry wants, or should be working on practical problems.' Canada needs a research-industry half-way house,' he concluded. 'There is no bridge between university research and industry in this country.'" (Brown, 2007: 62).

[58] Surprisingly (or perhaps not) CIAR was based on an idea advanced by the Director of the University of Toronto's Centre for Medieval Studies, John Leyerle.

Brown goes on to describe that, in December 1986, Mustard told the CIAR board of directors that a joint-venture, non-profit corporation should be created to oversee an applied research network. In January 1987, Mustard and Allan Crawford (a Canadian businessman) brought fifteen business leaders together at dinner at the University Club in Toronto and presented the idea to them. Twelve agreed in principle to support the idea, and each contributed C$ 25,000 a year to establish a non-profit organization that became known as Precarn. (Brown, 2007: 62-63).

Today Precarn focusses on "Intelligent Information and Communications Technologies" (iICT) and emphasizes its "unique collaboration model" [59] Precarn does not conduct research itself. Precarn's 2010 Annual Report states that its total revenues for 2009-2010 were C$ 18.4 million. The report does not break out these contributions by public and private shares (Precarn, 2010: 20) but it is known that Precarn receives significant federal funding support, most recently through a C$ 20 million grant Industry Canada for the period 2005-2010 (GOC, 2005: 132). The funding agreement with Industry Canada sets outs a variety of objectives for the funding, including: "improve knowledge exchange, technology diffusion and collaboration among industry, universities, community colleges and government laboratories across Canada." (Precarn, 2010b: 1).

Precarn's board of directors includes seven members drawn from private sector and one with a university affiliation. Funding proposals are reviewed by a voluntary Advisory Expert Panel, comprised of 15 members: five from the private sector, seven with university affiliations, and three from government research organizations (Defence R&D Canada, the Canadian Space Agency, and the Government of Saskatchewan's Research Council).[60]

CMC Microsystems

The Canadian Microelectronics Corporation (today known as CMC Microsystems) is another of the older intermediary organizations in Canada for encouraging U-B

[59] Precarn's 2010 Annual Report states that: "The Precarn model is unique in Canada's system of innovation as it is the only federally-funded program that brings together ICT technology developers, end-users/first customers, academic research talent, and public and private sector investors on collaborative R&D projects that address specific market opportunities." (Precarn, 2010: 4). But while this "model" was unique to Canada in 1986, it is perhaps less unique today.

[60] Precarn is positioned in this report as an intermediary organization for U-B collaboration even though it is has research funding functions. Later in this report its federal cousin, the Canadian Advanced Research and Innovation Network (CANARIE), is positioned as example of one means by which the federal government uses research funding to encourage U-B collaboration, even though CANARIE also has intermediary functions. The difference between Precarn Inc. and CANARIE (apart from their different areas of technological focus) is largely one of degree. Precarn's most recent 5 year funding agreement with the federal government was C$ 20 million. In contrast, CANARIE's most recent 5 year funding agreement with the federal government was C$ 120 million.

collaboration.[61] It was founded in 1984 as a not-for-profit company by 23 Canadian universities and a number of Canada's microelectronic firms. NSERC provided the start-up funding. The original business case presented in the joint university-industry request for NSERC funding highlighted the need to address skilled labour shortages in the microelectronics sector and the intense international competition the Canadian industry faced (CMC, 1985).

CMC's membership now includes 46 post-secondary institutions and 27 companies. CMC describes itself as a "4th Pillar" organization that leverages the skills, interests, and financial resources of the three-way (government, industry, university) partnership to enable and support the creation and application of microsystem knowledge. CMC Microsystems manages grants from the Canada Foundation for Innovation, the Ontario Innovation Trust, and additional funds from the provinces of Québec and Manitoba. CMC has a 14 member board of directors (seven with private sector affiliations and seven with university affiliations). In 2009-2010, the Chairman of the Board was Dr. Yvon Savaria, Professor, Department of Electrical Engineering, École Polytechnique de Montréal.

CMC Microsystems main source of financial support continues to come from NSERC. In February 2010, Canada's federal Minister of State for Science and Technology announced that NSERC would contribute a further C$ 40 million over 2010-2014 to CMC (GOC, 2009e). The Canada Foundation for Innovation, and the Governments of Ontario, Québec and Manitoba have also contributed funding (a total of C$ 17.9 million for microelectronics and photonics testing infrastructure and access).

Consortium for Research and Innovation in Aerospace in Québec (CRIAQ)

CRIAQ was created in 2002 by Québec based universities and aerospace companies as a not-for-profit organization to promote and manage pre-competitive aerospace manufacturing research projects. Its funding sources include: the Government of Québec's Ministry of Economic Development, Innovation and Export; NSERC; 15 universities; and 42 aerospace companies. CRIAQ has developed various partnerships with such other organizations as: the industry led and government supported Green Aviation Research and Development Network (GARDN); the federal government's Department of Transport; and a local development agency, Développement économique Longueuil (DEL).

CRIAQ is also one channel for funding of pre-commercial research projects under the federal government's Strategic Aerospace and Defence Initiative (SADI). For example, in January 2011 the federal Minister of Industry announced that the federal government's Industrial Technologies Office, a special operating agency of Industry Canada with responsibility for SADI, will make a repayable investment of C$ 13 million in a flight

[61] Federal government support for forest products research organizations, which also have some intermediation functions (today these organizations have been merged into a single organization, FPInnovations) date back to the early twentieth century. (Hull, 1986).

controls research project to be undertaken by Thales Canada Inc. and the École Polytechnique de Montréal. (GOC, 2011).

CRIAQ activities include promoting student training in aerospace related disciplines at universities and within industry, but its main activity is the management of "industry driven" research. CRIAQ has a developed a statement of principles for university-industry research projects, such as: "a minimum of 25% of the cost of the projects at the university is assumed by industry, the remaining coming from public funding to the universities." (CRIAQ, 2010). It has also developed an extensive protocol for how intellectual property developed during the course of the research projects is treated.

The CRIAQ board of directors includes 11 members with private sector affiliations and six with university affiliations. A representative from NSERC also sits on CRIAQ's board. In addition, there are 45 company, university, and provincial and government representatives that are designated as observers.

The Composites Innovation Centre Manitoba Inc. (CIC)

The CIC was created in 2003 with financial support from the federal government (Western Economic Diversification Canada has provided a total of C$ 10.3 million to the centre since its founding), the Government of Manitoba, the City of Winnipeg's economic development corporation, the National Research Council of Canada, the University of Manitoba, and Red River College (located in Winnipeg). CIC reports that its main competence is its ability to support the planning and implementation of industry sponsored projects (often U-B collaborative projects), including: assembling the most suitable partners; negotiating roles and responsibilities; developing a suitable funding model that combines industry and government contributions; and negotiating agreements on intellectual property.

The CIC is located at the University of Manitoba's Smartpark, which serves as a base of operations housing several full-time employees. It is also the location for the CIC's composites process and test laboratory which is available to university, industry and government researchers on a fee for service basis. The CIC is governed by an industry-led board of directors including representatives from: Boeing Canada, Magellan Aerospace, Motor Coach Industries, Structural Composites Technologies, Schweitzer Mauduit Canada and Acsion Industries.

Partnerships for Research on Microelectonics, Photonics and Telecommunications (PROMPT)

In 2003, the Government of Québec (and with additional NSERC) provided seed funding for the creation of PROMPT, a provincial not-for-profit corporation analogous to CMC Microsystems although with broader interests in the field of Information and Communication Technologies (ICT). PROMPT funds pre-competitive R&D partnerships that engage at least one company, and two universities. PROMPT seeks to: "Broker new relationships amongst researchers, developers and leaders in academia, industry, government and the investment community in Québec - and increasingly across Canada and around the world." (PROMPT, 2008: 4). PROMPT has a 13 member board of directors: eight from the private sector and five from Québec universities.

Canada Mining Innovation Council

In September 2007 the federal, provincial and territorial Mines Ministers endorsed the establishment of the Canada Mining Innovation Council (CMIC). CMIC was incorporated in 2008 as a not-for-profit corporation and with a small amount of in-kind support (provision of a secretariat) from Natural Resources Canada and the Canadian Institute of Mining. CMIC's overarching objectives are to: increase mining research, innovation and commercialization efforts; and increase the supply of highly qualified graduates from mining and earth sciences faculties.

One policy consideration for NRCan's contribution of seed-funding for the creation of CMIC was the lack of U-B collaboration in the mining and minerals sector. According to Lucas (2009):

> "In a series of [industry-university] workshops held in 2008, participants acknowledged the need for more collaborative relationships across the mining industry. There is a need for more exchange among academic institutions – universities, colleges and technical schools – and between academics, research centres and industry. Strategic decisions need to be made in the development of collaborative research initiatives to maximize funding opportunities and to cluster networks to attract private sector investments." (Lucas, 2009: 2).

CMIC board of directors is comprised of representatives from the private sector and higher education sectors (including the community college sector). A number of the specific initiatives CMIC supports (in partnership with other organizations) draw on federal and provincial government funding (Hynes, 2010).

The Centre for Drug Research and Development (CDRD)
(also a federal centre of excellence for commercialization and research)

The CDRD is a non-profit organization established in 2006. The CDRD offers a "drug development platform" but also has a separately incorporated commercial company that licenses technologies from affiliated university and government institutions. According the CDRD:

> "Our commercial arm, CDRD Ventures Inc. (CVI), acts as an interface between the Centre for Drug Research and Development and industry. The company in-licenses intellectual property generated from selected CDRD projects directly from affiliated institutions' technology transfer offices or inventors. We fund and advance programs through preclinical development, with the goal of developing robust and complete technology dossiers to support successful commercialization. …We also consider technologies for in-licensing as well as

> opportunities for strategic partnerships with pharmaceutical and biotech companies to attract funding and advance promising technologies through development. Programs will eventually be out-licensed to pharmaceutical or biotech partners or spun off as life sciences companies. Profits from CVI flow back to CDRD to continue to support ongoing drug-development projects, operations, facility improvements, and equipment renewals. CVI will help CDRD become self-sustaining." (CDRD, 2010, Web).

The CDRD is located on the campus of the University of British Columbia (but with access to facilities at Simon Fraser University and the BC Cancer Agency). It has affiliation agreements with several universities across Canada (in November 2010 it signed an affiliation agreement with Dalhousie University in Halifax) and also with a number of other intermediary organizations, including the MaRS Discovery District in Toronto.

The CDRD received launch funding of C$ 8 million from the federal Canadian Foundation for Innovation. Other funding sources have included: the Government of British Columbia, the Michael Smith Foundation for Health Research (funded by the Government of British Columbia), the federal government's regional development agency Western Economic Diversification Canada, and the Canadian Institutes for Health Research. In 2010, the federal government announced that the CDRD would receive further funding (C$ 14.95 million) through its Centres of Excellence in Commercialization and Research program.

Alberta Centre for Advanced Microsystems and Nanotechnology Products (ACAMP)

ACAMP is one of Canada's newest and government supported sectoral intermediary organizations. It is a non-profit organization created in 2008 as part of the Government of Alberta's C$ 180 million nanotechnology strategy and has also received substantial federal funding support. ACAMP provides "a path to commercialization" for established firms, small start-up companies and researchers. As described by ACAMP's CEO Ken Brizel:

> "The ACAMP team works with clients to coordinate product commercialization including fabrication, packaging and assembly using resources throughout Alberta as well as partnerships with NanoFab at the University of Alberta, the University of Calgary's Advanced Micro/Nanosystems Integration Facility, the National Institute for Nanotechnology (NINT), and the Microsystems Technology Research Initiative (MSTRI). (Brizel, 2009: 2)

ACAMP's board includes six private sector members and a University of Alberta faculty member. ACAMP's board of directors is chaired by the CEO of TEC Edmonton. TEC (Technology, Entrepreneur and Company Development Edmonton) is itself a not-for-profit joint venture between the University of Alberta and the City of Edmonton's Economic Development Corporation and that describes its mission as: "Through its people, networks, programs, and facilities, TEC Edmonton develops the region's innovation outcomes by: helping build successful innovation-based companies; commercializing technology from private, university, and public sources; and promoting innovation and new enterprise development." (TEC, 2010: 2).

ACAMP has received funding of C$ 11.5 million to date: C$ 8 million from the Alberta Government's Department of Advanced Education & Technology; and C$ 3.5 million from Western Economic Diversification Canada (WD – a federal regional development agency). In October 2010, Prime Minister Stephen Harper announced that the federal government would provide ACAMP with a further C$ 1.9 million through WD and said:

> "Hear me on this: reaching the market is the end goal. This government will not let Canadian innovative ideas languish on the blackboard." (GOC, 2010p)

4.3.1.2 Horizontal Organizations

Examples of horizontal organizations with U-B research intermediation as a core activity, and which receive financial support from federal and provincial governments, are fewer in number than those with a strong sectoral focus. However, they exhibit at least as much if not more diversity in their form and origins than the sector organizations. Among the examples provided below are: regional and national commercialization networks; a provincial government crown corporation (Innovacorp); an organization selected through public tender to deliver government programs (ISTPCanada); an entity that has now become one of Canada's premier and world-renowned organizations to "better connect the worlds of science, business and government" (MaRS Discovery District); and a not-for-profit corporation created to deliver the Government of Ontario's funding programs to encourage U-B research collaboration (OCE Inc.).

Regional and national commercialization networks

There are four major regional commercialization networks in Canada, all having members representing the higher education institution sector and often with members from the private sector. The regional networks are: Springboard Atlantic; Les Bureaux de liaison entreprises-universités (Les BLEUs); the Ontario Society for Excellence in Technology Transfer (OnSETT); and Westlink Innovation Network Inc.[62] These networks are founding members of the national commercialization organization, the Alliance for Commercialization of Canadian Technology (ACCT).[63]

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[62] There are many other provincial commercialization networks, some of which receive provincial government funding. In Ontario, the Ontario Commercialization Network (OCN) is a formal government program of the Ontario Ministry of Research and Innovation.

[63] The ACCT was created in 2005. Its membership comprises more than 110 academic-based research organizations including universities, hospitals, colleges and polytechnics, including over 400 knowledge and technology transfer/industry engagement practitioners. ACCT Canada also has formal relationships with the Association of University Technology Managers (AUTM) in the United States, PraxisUnico in Europe and Knowledge Commercialisation Australasia (KCA) in

Both federal and provincial governments have provided financial support for these networks, in some cases providing core funding and in all cases through sponsoring specific activities and events. For example:

- **Springboard Atlantic Inc.** This not-for-profit corporation was established in 2004 by 14 Atlantic Canada universities and four community colleges. Springboard Atlantic's main areas of activity are:

  - technology transfer and commercialization of research at each of the member institutions and at other research centres in Atlantic Canada (e.g., assessing new technologies, filing patents, copyrights and intellectual property claims, and maintaining and managing licenses);

  - industry liaison and development of commercial partnerships (e.g., facilitating private sector sponsored events and meetings, negotiating comprehensive agreements and accessing small business programs for industry support);

  - development of spin-off companies and joint ventures with industry (e.g., recruiting experienced management, business planning, and helping to find investors); and,

  - administration of government SME programs for sponsored research at universities.

  Springboard Atlantic has an eleven member board of directors: six university representatives, one community college representative, and four private sector representatives. Springboard's total funding over the 2004-2008 period was C$ 11.3 million, of which: C$ 5.4 million (47 percent) came from the federal government's Atlantic Canada Opportunity Agency (ACOA); C$ 2.9 million (26 percent) came from university and college members; and C$ 2 million (18 percent) came from NSERC (Springboard, 2008: 9)

- **Westlink Innovation Network Ltd.** WestLink is a not-for-profit corporation founded in 1999 to increase the rate that innovations from research institutions, including universities and colleges, are transitioned to the marketplace. Today, WestLink has 33 university and college institutional members and 150 private sector members. WestLink's board of directors includes five members with university and community college affiliations and five with private sector affiliations. Since its foundation, both federal and western Canada provincial governments have provided financial support for WestLink operations. For example, in 2002 the federal government provided C$ 600,000, and four western provincial governments C$ 185,000, to WestLink's core funding (GOC, 2002b).

Australia as well as developing relationships with Canadian industry associations, the Federal Partners in Technology Transfer (FPTT) and federal and provincial government departments and agencies.

ISTPCanada Inc.

ISTPCanada is a not-for-profit corporation selected (through public tender) by the federal government to deliver projects under bilateral S&T agreements with China, Brazil, India, Israel, and the State of California. The organization is governed by an eleven member board of directors: seven from the private sector and four with university affiliations. For the first full year of its operations (2008), it received C$ 491 thousand from governments (primarily from the federal government) for its operations. ISTPCanada is both an assessment body for various project proposals submitted by eligible applicants under the different bilateral S&T agreements and a delivery vehicle for federal government funding of accepted proposals (C$ 20 million over five years beginning in 2007). Funding criteria applied by ISPTCanada include university, college and industry participation.

Innovacorp[64]

The Government of Nova Scotia established Innovacorp as a Crown Corporation in 1995. The corporation's legislated objectives do not include mention of encouraging U-B collaboration, but today Innovacorp describes one its main areas of activity as providing incubation, mentoring and investment services to support early stage technology commercialization of post-secondary institution research.[65] Innovacorp's 2010-11 business plan states:

> "Both the provincial and federal governments have invested in infrastructure designed to increase the commercialization of university research. The business building component of university and college curriculum in most cases is lacking, and there are few formal ties between university research and the innovation capital markets. In this context, Innovacorp must continue to increase its efforts by effectively partnering with entrepreneurs who are active in Nova Scotia's post-secondary institutions." (Innovacorp, 2010: 9).

In July 2010, the Premier of Nova Scotia, the Honourable Darrell Dexter, received advice and recommendations from Donald Savoie, Canada Research Chair in Public Administration, on how to improve Nova Scotia's economic development. Savoie's report highlighted and commended Innovacorp's role in encouraging U-B collaboration in the province in the following terms:

[64] The Government of Newfoundland and Labrador has also established a Crown Corporation to deliver on its innovation policy objectives. Its R&D Corporation (RDC) was created under the *Research and Development Council Act* as passed by the Legislative Assembly of Newfoundland and Labrador in December 2008. The corporation's legislated objectives do not include mention of encouraging U-B collaboration and many of its functions (its innovation voucher program being one exception) are oriented to delivering government programs.

[65] Innovacorp also has some venture capital activities.

> "Individuals whom I consulted applauded Innovacorp for its ability to support early stage firms (through its incubation program), and to provide advice and support at critical moments in a firm's development. …Innovacorp has become an important player in promoting closer cooperation between university-based research and the private sector. It appears to have gained the confidence of both sides. **Recommendation 19:** *The provincial government should look to Innovacorp in any further efforts to promote cooperation between the universities and the private sector.*" (Government of Nova Scotia, 2010: 34). [emphasis and italics in the source document].

MaRS Discovery District (Toronto)

The MaRS Discovery District organization was founded in 2000 by a group of business, university and community leaders in Toronto. The group – led by University of Toronto president emeritus Dr. John Evans – raised initial funds from 13 private individuals and corporations and obtained further support from the private sector, academic and federal, provincial (Ontario), and municipal (Toronto) governments. Today MaRS is governed by a 15 member board of directors and 24 staff members. With a combined public sector (federal, provincial, municipal) capital investment of C$ 95 million, MaRS reports that it has leveraged private capital investment of C$ 222 million.

MaRS initially focused on overseeing the financing and construction of a physical "convergence facility" in downtown Toronto, adjacent to the University of Toronto and the city's financial district. MaRS has expanded its range of activities over time. It now offers market intelligence, entrepreneurship education, seed capital and access to "customer and partner networks", including university-based research organizations. MaRS sectoral interests now include: advanced materials and engineering; clean technology; information and communications technology; life sciences and health care; and social innovation. It also manages some Government of Ontario programs, including the Business Mentorship and Entrepreneurship Program and the Investment Accelerator Fund (in partnership with Ontario's Centres of Excellence).[66] In 2008, one of MaRS' program elements, MaRS Innovation, was designated as a federal centre for commercialization and research and received C$ 14.95 million in federal funding.

[66] Until 2011, MaRS also administered the Government of Ontario's Summit Awards in medical research. First established in 2005, this award was one of Canada's richest prizes in medical research, with each recipient receiving C$ 5 million over five years, derived from a $2.5 million contribution from the Government of Ontario and matched by C$ 2.5 million from the sponsoring institution (typically a research hospital or university). The Government of Ontario's contribution to the program (C$ 25 million) had been awarded by 2010. As of February 2011, no new funding for the program has been announced by the provincial government.

OCE (Ontario Centres of Excellence) Inc.

OCE Inc. is a not-for-profit and provincially incorporated entity launched in 2004. [67] It was mandated to deliver the Ontario Government's Centres of Excellence program. This program comprised four university-based centres that collectively were intended to promote the economic development of Ontario through directed research, commercialization of technology and training for highly qualified personnel. The underlying premise (and operating focus) of the centres was that they would encourage business-university research collaboration and the commercialization of results. Today OCE Inc. continues to administer the centres (there are six being funded today) but also administers a range of other provincial government programs designed to encourage U-B collaboration. The story behind OCE's creation is one of both experimentation in government program delivery and of the role of political circumstances.

The Centres of Excellence program was originally established in 1987 and, between 1987 and 2003, the government invested C$ 500 million in the centres. The centres, four initially, were autonomous non-profit legal entities. They were funded through negotiated research contracts (not research grants) with the then Ministry of Industry Trade and Technology. The research contracts were extensive and included detailed reporting and accountability requirements and periodic review mechanisms (Bell, 1996).

By 2003, however, these accountability and funding arrangements were being called into question. For instance, the Ontario Auditor General's 2003 annual report highlighted a number of shortcomings in the "monitoring process" for demonstrating that the Ontario Centres of Excellence use public resources prudently and in compliance with defined performance expectations (Government of Ontario, 2003: 182).[68] Even as these concerns were being voiced, officials within the Ontario government were developing a plan to move the delivery of the program to a third-party organization: "The Ministry is currently implementing a new governance structure for the Centres through the Ontario Centres of Excellence Inc., a not-for-profit corporation that will be under contract to the Ministry to manage the Centres. The contract will set out performance measures and requirements for accountability and good governance." (Government of Ontario, 2003: 183).

Political circumstances also helped bring about change in how the Centres of Excellence program was delivered. The October 2003 provincial election brought to power Dalton

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[67] OCE Inc. was formally incorporated in July 2003.

[68] The Auditor General was also critical of the government's accountability arrangements for its other innovation support programs, including those delivered through the C$ 844 million Ontario Innovation Trust (an arms-length organization established by the Ontario Government in 1999 and which, by 2009, had spent all of its allotted capital). The Auditor General stated in 2003 that: "A major concern was that the Ministry had committed to spending $4.3 billion without an overall strategic plan to set parameters and consistent policies for existing programs or to guide the development of new programs to meet the objectives of promoting innovation, economic growth, and job creation." (Government of Ontario, 2003: 166).

McGuinty’s Liberal Party. The Liberal Party election platform drew attention to the example of the Georgia Research Alliance (as described in section 5.3.1.2 of this report, the Georgia Research Alliance is an intermediary body in the US State of Georgia whose functions include encouraging U-B collaboration) as one model the Government of Ontario might draw upon:

> “We will help bring good ideas to market. Research is only half the innovation story. The other half is bringing good ideas to market. Learning from successful jurisdictions like Georgia, we will create a provincial research commercialization project that will support university and private sector efforts to bring new ideas to market. …Georgia’s economy blossomed in the 1990s because of a relentless focus on commercializing research. Through a co-operative effort between the public, private and academic sectors, Georgia leapt ahead of other jurisdictions in innovation performance, outpacing even those with larger basic research budgets.” (Ontario Liberal Party, 2003: 23)

On March 31, 2004, the then Ontario Ministry of Economic Development and Trade signed a contract OCE Inc. for delivery of the Centres of Excellence program. In 2004, the Chairman of OCE Inc., David McFadden, identified four major factors that made OCE a more effective vehicle for delivering the program than under the previous arrangements:

> “First, there is the crucial issue of brand identity. We are proud of the names that the individual centres have made for themselves not only in Ontario, but also beyond our provincial borders. However, in order for us to be able to fully leverage the strengths of the individual centres, **it was critical to strengthen the market recognition of the OCE Program as a whole**. The merger provides us with a strong, unified brand identity that will enable more effective promotion of OCE Inc.’s capabilities and of Ontario’s innovation capacity to provincial, federal and international audiences.
>
> Second, despite their impressive track records, given the realities of the globalized environment in which we operate, **any one of the centres by itself was competitively limited due to its size**. Now as a merged entity comprising the four centres, OCE Inc. has a critical mass that will enable it to contribute even more to the economic and social future of Ontario.
>
> Third, as a unified “Ontario” centre, **there is now tremendous potential for OCE Inc. to explore avenues of funding that have not been traditionally pursued, including provincial and federal government agencies, and private sector funders such as research foundations.** And let us not forget the challenges we face in retaining skilled knowledge workers in Ontario and in Canada. In developing new divisions, new concepts, new strategic alliances and new research ideas, OCE Inc. will be able to offer exciting growth opportunities for employees and interesting challenges for Ontario’s talented research community to keep them productive within our own borders.

> Finally, though OCE Inc. will continue to work within the key areas defined by the four centres, **the new structure will allow more cross-pollination throughout the entire program, making it easier to meet emerging market needs.** Expanding into new fields of activity such as energy, the environment, and life and health sciences will further increase our potential to add benefit to Ontario's economy and enhance the quality of life within the province." (OCE Inc., 2004: 1). [emphasis added].

OCE Inc.'s activities have expanded beyond delivering the Centres of Excellence program since 2004 although that remains a core activity for OCE Inc. During 2008-2009, OCE Inc. invested C$ 25.8 million in the centres and leveraged C$ 40.1 million from industry partners (Government of Ontario, 2010: 1).

In June 2009 the Ontario Government introduced its new Ontario Networks of Excellence (ONE) policy framework for delivering a wide range of innovation and research programs. Within this framework, OCE has been selected to administer all the Ontario Ministry of Research and Innovation programs for "Industry-Academia Collaborative Partnerships." (See section 4.4.3 for a summary description of these programs). It was in the context of this broadened mandate for encouraging U-B research collaboration (and improving commercialization of research) that OCE Inc.'s President and CEO, Dr. Tom Corr, reported in 2010 that:

> "The real secret to what OCE does is our business development capability. Our business development specialists go out and literally explore the labs of academia. They ask "what's new?" They make it their business to maintain valuable contacts with leading Ontario companies in sectors including energy, communications and information technology, photonics, earth and environmental technologies, health, and manufacturing and they ask them, "what do you need?" …Putting academia and industry together to create a new product or technique is no easy task and requires the successful application of our specialized investment programs and the unique skill sets that reside within OCE. I've said before that industry can't ask for what it doesn't know about and that's where OCE comes in – we are the connector. And as the connector, OCE's business development model will be shifting to be more "industry-pulled" rather than "academia-pushed." (OCE, 2010: 3).

As of 2010, OCE's nineteen member board of directors included eleven members with private sector affiliations and six with university affiliations. A Director General from the National Research Council of Canada also sits on OCE's board as does the CEO (ex-officio) of OCE Inc. There are two Government of Ontario officials who are observers (OCE Inc., 2010: 20).

4.3.2 Other Enabling Measures

Federal and provincial governments have put in place an extensive range of other enabling measures to encourage U-B collaboration, including: various U-B collaborative training and internship programs;[69] initiatives to co-locate government research assets with those of universities and industry; and creating industry-led sectors skills councils (these councils predominantly work at the community college level but have expressed interest in working more closely with universities).

Federal Industrial Research and Development Internships (FIRDI)

The federal government's 2007 Budget announced C$ 4.5 million in funding for FIRDI and to be administered through NSERC. The program partners graduate students and post-doctoral candidates with businesses and supports up to 1,000 internships each year. (GOC, 2007: 205). The federal government's March 2010 budget allocated additional funding for the program of C$ 34.4 million over five years starting in 2011-12.

Collaborative Research and Training Experience (CREATE) Program

This federal program, also administered by NSERC, was launched in May 2008 and invites funding proposals for "innovative training programs" at universities and colleges. The CREATE program is designed to improve "the mentoring and training environment for Canadian researchers of tomorrow by improving areas such as communication, collaboration and professional skills, as well as providing experience relevant to both academic and non-academic research environments." At least 60 percent of the CREATE funding (C$ 32 million over six years) is allocated to the four priority areas identified in the federal government's 2007 S&T Strategy: environmental science and technologies; natural resources and energy; health and related life sciences and technologies; and information and communications technologies.

Co-location of government research assets with those of universities and businesses

Doern and Kinder (2007) have documented the long history of policy development and debate with respect to the mission, role, and organization of government performed science in Canada. Since 2007, the federal government's enabling role in encouraging U-B collaboration has included decisions taken on the deployment of its own public science assets. For example, the federal government's 2007 budget provided funding for

[69] A number of internship programs may fall under the broader category of co-operative education. The Canadian Council of Learning reports that: "There is a scarcity of data on the availability of, and participation in, co-op education in Canada. …The available data [2004] suggest that there are approximately 80,000 Canadian students enrolled in post-secondary co-op education, two-thirds of whom are at the university level. Given a university enrolment of more than one million in Canada, it is clear that participation in co-op education is relatively rare among Canadian students. However, co-op students appear to derive a number of benefits from their work placements, suggesting that opportunities for co-op education should be expanded in Canada."(Canadian Council on Learning, 2008: 2-3).

the transfer of the Department of Natural Resources' Materials Technology Laboratory (CANMET) from Ottawa to the new facilities at McMaster Innovation Park in Hamilton, Ontario. According to the federal government:

> "This new location, in the heart of Canada's automotive and steel manufacturing industries, will foster synergies among industry, academia and government research. Budget 2007 provides $ 6 million in 2008–09 to implement the relocation." (GOC 2007: 201).

The federal government also announced in 2007 that: "The Government will launch an independent expert panel that will consider options for transferring federal laboratories to universities or the private sector."(GOC, 2007: 202). The resulting panel report (GOC, 2008b) identified five potential candidates for transfer and provided a framework for guiding the development and evaluation of opportunities for alternative management arrangements. (GOC, 2008b: 3). The federal government has not issued a formal public response to the panel's recommendations.[70]

Sector Skills Councils

Beginning in the 1980s, the federal government has provided funding (over recent years some C$ 40 million annually) for a system of thirty-three employer-led sector councils. Provincial and territorial governments also provide funding to the councils. The federal government's Department of Human Resources and Skills Development has set out four objectives for its support of the councils, including "a learning system that is informed of, and more responsive to, the needs of industry (Human Resources and Skills Development Canada, 2010 Web).

Several of the councils include university members (e.g., Ryerson, McMaster and York universities are members of the ICT sector council and a faculty member of the University of Waterloo's Engineering Department sits on the board of directors of the Plastics Sector Council). However, the sector councils have primarily engaged with Canadian colleges rather than with universities. In 2007 the Canadian Alliance of Sector Councils commissioned a report on the relationships between the sector councils and universities. While the report recommended that stronger linkages be developed, this has not yet led to significant change in the level of engagement between the sector councils and universities. (In 2009 the Alliance initiated a pilot project though the Sprott School of Business, Carleton University, to bring interested sector councils and universities together and discuss mutual interests in the single disciplinary area of business management).

[70] The five federal laboratories identified as "early candidates" for transfer were: Agriculture and Agri-food Canada's Cereal Research Centre (which, in any case, was suffering from "rust-out" and with new facilities to be built, possible at the University of Manitoba's "Smartpark"); Environment Canada's Wastewater Technology Centre; Health Canada's Safe Environments Laboratories; the National Research Council's Aerospace Manufacturing Technology Centre; and Natural Resources Canada's Geoscience Laboratories.

4.4 Canadian Governments as Funders

The federal government funded C$ 5.7 billion of R&D or 19.1 percent of total Canadian Gross Expenditure on Research and Development (GERD) of C$ 29.9 billion in 2009. Provincial Governments funded C$ 1.5 billion of R&D or 5 percent of total R&D funding in 2009. According to Statistics Canada, the three most significant objectives for federal R&D funding in 2008-2009 were: protection and improvement of human health (C$ 1.6 billion), industrial production and technology (C$ 1 billion) and non-oriented research (C$ 754 million). (GOC, 2010h: 8).

It is a significant challenge to navigate through the dense web of federal and provincial extramural funding programs for R&D and even more so to determine which programs (and how much public money they represent) have encouraging U-B collaboration as a primary objective. In this section, federal and provincial government funding measures to encourage U-B collaboration are presented in three categories:

- funding programs and conditions of the three federal research granting councils (there are individual council programs and a suite of "tri-council" programs);
- other federal and provincial government research funding programs; and,
- other government fiscal incentives (e.g., R&D tax credits and federal government defence procurement programs).

Table 8 (next page) summarizes federal government funding programs that, as an exercise in qualitative judgement, have encouraging U-B research collaboration as a primary objective. Total annual expenditures under these programs are conservatively estimated to be at least C$ 370 million annually. This estimate is based on publically available data sources (see Annex IV). To help place this estimate of federal spending directly targeted at encouraging U-B collaboration in perspective, it represents: 6.4 percent of total federal R&D expenditures of C$ 5.7 billion in 2009; and 41.2 percent of the C$ 892.4 million in R&D funded by the business sector and performed in the higher education sector in 2008-2009.

Table 8
Canadian Federal Government Funding Programs with Encouraging U-B Collaboration as a Primary Objective: Estimates of Annual Expenditures

Notes	Federal Funding Programs	Estimated Annual Funding (C$ M)
	Individual Federal Research Council Programs	
1	NSERC	181.0
2	CIHR	16.4
3	SSHRC	36.0
	Subtotal Individual Research Council Funding Programs	**233.4**
	Tri-Council Funding Programs	
4	*Business-Led Networks of Centres of Excellence*	11.5
5	*Centres of Excellence for Commercialization and Research*	57.0
	Subtotal Tri-Council Research Funding Programs	**68.5**
	National Research Council of Canada	
6	IRAP (notional allocation of 17% of total IRAP budget of $ 137.6 M in 2010-2011. Excludes stimulus spending)	23.4
7	NRC Cluster Initiatives (notional allocation of 10% of total expenditures on cluster initiatives)	8.3
8	NRC Institutes (notional allocation of 10% NRC spending on its Institutes in 2009-2010)	30.0
	Sub-total NRC	**61.7**
9	**Federal Regional Development Agency Programs**	5.0
	ESTIMATE OF TOTAL FEDERAL FUNDING WITH ENCOURAGING U-B COLLABORATION AS A PRIMARY OBJECTIVE	**368.6**
	Other illustrations of annual federal funding, some portion of which might be also be attributed to achieving U-B collaboration objectives	
	CANARIE	24.0
	Precarn	4.0
	CMC Microsystems	8.0
	Tri-Council Networks of Centres of Excellence (NCE) Program	71.8
	Sector Skills Councils	40.0
	SR&ED Tax Credit (projected tax expenditures 2010)	3,500.0

Sources and Notes: Developed by the author. See Annex IV for data sources and notes.

4.4.1 Funding Programs and Conditions of the Federal Research Granting Councils

The main federal funding institutions for research at Canadian universities are: the Natural Sciences and Engineering Research Council; the Canadian Institutes of Health Research; and the Social Sciences and Humanities Research Council. Each council has developed their own suite of research granting programs for universities some of which are conditional upon universities partnering with business organizations. There are also several jointly administered "Tri-Council" funding programs.[71]

4.4.1.1 Individual Research Council Programs

Natural Sciences and Engineering Research Council (NSERC)

NSERC's governing statute requires that it promote and assist research in the natural sciences and engineering, other than health sciences. NSERC receives funds appropriated by Parliament (C$ 1.1 billion in 2010-2011). NSERC has eight main programs geared to encouraging U-B partnerships in research (see Table 9 next page).

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[71] Although governance structures of the federal research granting councils are not addressed in this report, it should be observed that the composition of their governing councils has changed over the past decade to include greater representation from non-academic organizations. This has development has not gone unnoticed. For instance, the Association of Universities and Colleges of Canada magazine, *University Affairs*, reported in March 2010 that: "At SSHRC, nine of its 19 governing council members are from industry and non-profit agencies, up from four in 2000. At NSERC, 10 of its 18 members are non-academic appointees compared to eight in 2000. …At CIHR, by contrast, with 17 council members, Dr. Prigent is the fifth member from outside academe, and most of the others are from public health agencies. …Governing council appointments are made by the federal cabinet. The three councils have rigorous conflict-of-interest rules and don't make decisions about grant funding. That is done by peer-review committees. But the governing councils set the agenda and broad strategic vision of the granting agencies." (Tamburri, 2010: 33)

Table 9
NSERC Industry Partnership Programs and funding (most recent year available)

NSERC Partnership Programs (excludes Tri-Council Programs)	Objective	Annual Program Expenditures in 2009-2010	Financial Contribution Required from Business?
Strategic Project Grants	Funds early-stage project research in targeted areas (i.e. aligned with federal S&T priorities). Expected results include; increased participation of Canadian-based companies and/or government organizations in academic research; and enabling the transfer of knowledge/technology and expertise to Canadian-based companies or to government organizations to strengthen public policy.	**C$ 61.0 million**	Not required.
Collaborative Research and Development (CRD) Grants	Helps companies conduct an identified R&D project in collaboration with academics. CRD projects can be at any point in the R&D spectrum. Eligible collaborations include focused projects with short- to medium-term objectives, as well as discrete phases in a program of longer-range research.	**C$ 52.5 million**	At least one-half of the amount requested from NSERC.
Strategic Network Grants	Funds large-scale, multi-disciplinary research projects in targeted research areas that require a network approach and that involve collaboration between academic researchers and Canadian-based organizations.	**C$ 31.9 million**	Not required.
Industrial Research Chairs	Help universities build the critical mass of expertise and long-term relationships with corporate partners in areas of research that are of importance to industry and recruit senior-level researchers and research leaders from industry or other sectors.	**C$ 27.0 million**	Must contribute an amount equal to the amount requested from NSERC
Ideas to Innovation Program	Funds university researchers for R&D activities leading to technology transfer to a new or established Canadian company.	**C$ 6.3 million**	Phase IIa, 1/3 of project costs in cash; phase IIb, 1/2 of project costs in cash and in kind.
Engage Grants Program	Provides short term support for academics and companies (who had previously not worked together) to solve a company specific problem.	**C$ 1.8 million**	Not required.
Interaction Grants Program	Fosters new relationships between companies and academic researchers (maximum grant C$ 5 thousand).	**C$ 365,000**	Not required.
Partnerships Workshops Program	Brings together academic researchers and companies through workshops to generate new university-industry-government partnerships that will lead to new collaborative research activities.	information not available (funding is likely minimal)	Not required.

Source: Developed by the author based on NSERC Departmental Performance Reports.

Note: Other NSERC programs that invite industry support and participation include: Industrial Postgraduate Scholarships (IPS); Industrial R&D Fellowships (IRDF); Northern Research Internships (NRINT); Industrial Undergraduate Student Research Awards (USRA); and Chairs in Design Engineering.

NSERC research partnership programs are subject to various industry participation conditions. For example, NSERC's Strategic Project Grants Program (C$ 61 million in 2009-2010) requires that there must be significant involvement from an industrial partner, but a cash contribution from the partner in not required. In contrast, NSERC's Collaborative Research and Development Grants Program (C$ 52.5 million in 2009-2010) requires a cash contribution from the industrial partner (see Table 10 below).

Table 10
NSERC Collaborative Research and Development (CRD) Grants Program
Program Summary

Who manages funds?	University and lead professor.
Use of funds	Direct costs of research, such as the salaries of student, postdocs, and research assistants, and the costs of equipment, materials, services.
Typical grant range and type of partners required	C$ 10,000 to C$ 500,000; Canadian-based companies, industry associations, public utilities.
Minimum company contribution and minimum cash contribution.	Must contribute an amount equal to the amount requested from NSERC, must collaborate on the project, and at least one partner must have the ability to exploit the results. At least one-half of the amount requested from NSERC must be a cash contribution.
Is industrial in-kind contribution recognized?	Yes, up to the level of cash contribution.
Is the contribution eligible for the SR&ED federal tax incentive?	Yes, subject to SR&ED eligibility rules and amounts.
Evaluation method	All proposals are peer-reviewed by external reviewers. In addition, proposals requesting C$150,000 or more per year from NSERC will be reviewed by the Advisory Committee on University-Industry Grants (ACUIG); and those requesting C$ 200,000 or more per year from NSERC will be reviewed by the ACUIG and a site visit committee.

Source: NSERC Website accessed June 2010 at: http://www.nserc-crsng.gc.ca

The Canadian Institutes of Health Research (CIHR)

The CIHR was created by federal statute in 2000 (it replaced the former Medical Research Council of Canada) and consists of thirteen institutes representing "communities of health interest" rather than separate bricks and mortar facilities. The CIHR received statutory appropriations of C$ 980.8 million in 2010-2011 and reports to Parliament through the federal Minister of Health.[72]

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[72] CIHR's founding statute states: "The objective of the CIHR is to excel, according to internationally accepted standards of scientific excellence, in the creation of new knowledge and

CIHR's 2009-2014 Strategic Plan includes four directions, one of which is "accelerate the capture of health and economic benefits of health research." The plan states that:

> "Through its commercialization and innovation strategy, CIHR will continue to catalyze collaborations between industry and the research community to translate health research into improved health products, technologies, tools and services. CIHR will continue to provide incentives to researchers to engage the private sector and address its research needs. CIHR will collaborate with federal and provincial departments and agencies, private sector partners and others to move health research along the innovation pipeline into health and economic benefits for Canadians." (GOC, 2009g: 25).

The CIHR operates a variety of research commercialization programs and related grants to encourage collaboration between academia and industry. For 2010-11, the CIHR has allocated C$ 16.4 million to its own research commercialization programs while also contributing a further C$ 29.1 million for health research commercialization programs jointly administered by the three federal research funding councils (see section 4.4.1.2 of this report). However, the CIHR also reports that its total spending on "Knowledge Transfer and Commercialization" was C$ 72.1 million in 2009, compared to C$ 590.2 million for "Advances in Health Knowledge" and C$ 275.6 million for "People and Research Capacity." (GOC, 2010g: 36).

The C$ 72.1 million allocated by the CIHR for knowledge transfer and commercialization (and that may be considered as a proxy indicator for funding of U-B collaboration) is a relatively small amount compared to the CIHR's total budget. No criticism is implied or should be attached to this observation. Instead, the funding allocation may reflect that:

- the U-B relationship in this area may be mediated and shaped not so much by funding or funding conditions (although of course federal funding is important for the conduct of research by extramural performers) as by the regulatory environment, including: rules respecting the conduct of clinical trials; the federal regulatory regime for safety and efficacy of drugs and other human health products; and the intellectual property regime; and,

- the bio-medical-pharmaceutical industry requires little incentive to collaborate with universities (or other public research institutions) perhaps because in no other industry sector is university research so critically important and are links so well established.

Two examples of CIHR grant programs to support U-B collaboration are the Industry Partnered Collaborative Research (IPR) Program and the Proof of Principal (PoP) grant program.

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its translation into improved health for Canadians, more effective health services and products and a strengthened Canadian health care system." (S.C. 2000, c.6)

The IPR program was launched in 2009 and replaced a smaller program targeted at SMEs. IPR grants are awarded on a competitive basis for collaborative research with up to C$ 5 million available for each round of competition and each grant providing up to C$ 500 thousand per year for up to 5 years. An academic researcher is responsible for applying for the grant. Industry partners must have demonstrable ability to apply the results of R&D itself or through agreements with other companies having the capacity to produce and market products and processes.

The goal of the PoP Program is to facilitate and improve the translation of knowledge and technology resulting from academic health research. The maximum amount per grant is: C$ 160,000 for up to one year for phase I proposals (where research is at a stage beyond discovery-driven research and yet results are of uncertain utility or insufficiently developed to be of interest to relevant receptor companies, organizations, and potential investors); and up to C$ 300,000 for phase II proposals (where the principle of the intellectual property involved has already been proven and the applicants have identified partners willing to invest in the new technology).

The Social Sciences and Humanities Research Council (SSHRC)

The SSHRC was created by federal statute in 1977 and inherited the research granting functions formerly exercised by the Canada Council. The SSHRC received federal government funding of C$ 363 million in 2009-2010 (plus an additional C$ 325 million to fund the federal government's program to support the indirect costs of research at Canadian universities).

The SSHRC launched a new competition for Partnership Grants with a total budget of C$ 28 million over seven years in July 2010. According to SSHRC, the new grant program provides:

> "…flexible funding opportunities to enable postsecondary institutions and organizations from the private sector, government organizations, non-profit and community-based organizations to develop and sustain collaboration in research and knowledge mobilization. Formal partnerships across disciplines and sectors allow sustained work over several years on issues or opportunities of shared interest, with results benefiting users within the partnership and beyond. SSHRC's new approach to partnerships allows for greater flexibility by applicants to design a partnership model most likely to produce valuable results for Canadians and provide training opportunities for students, while adhering to the highest standards of excellence. Within its new Partnerships opportunities, SSHRC has identified priority thematic areas such as Digital Media, and Innovation, Leadership and Prosperity, in order to support new cross-sectoral or interdisciplinary partnerships focused on areas of opportunity for Canada." (GOC, 2010c: 3-4).

The SSHRC's Partnership Grants are in the range of C$ 500,000 to C$ 2.5 million over 4 to 7 years (requests for lower or higher amounts will be considered by SSHRC). The

SSHRC has issued a list of possible formal partnership approaches (GOC, 2010d: 30-31) that includes reference to partnerships with the private sector. As we shall see later in this report (section 5.4.1), an analogous type of informal guidance on what is meant by partnership approaches has also been taken by the US National Science Foundation with respect to the application of its grant award criteria.

The SSHRC has also funded an Innovations Systems Research Network (ISRN) that includes four academic sub-networks: in Atlantic Canada, Québec, Ontario and Western Canada. In 2001, the SSHRC awarded ISRN a Major Collaborative Research Initiative grant to undertake a five year program of research on "cluster-driven" innovation in Canada (with additional support provided in 2006 from the National Research Council, Statistics Canada and several other federal and provincial departments and agencies).

4.4.1.2 Tri-Council Funding Programs

There are a suite of tri-council (NSERC, CIHR, and SSHRC) granting programs which are conditioned on partnerships between universities, business and other organizations.

Networks of Centres of Excellence (NCE) Program

The federal NCE program was launched in 1989 and supports university-based research networks in such areas as: human health and development; photonics; natural resources; the environment; and advanced manufacturing technologies. There are 20 NCEs in operation as of January 2011. The networks are selected through an open competition and an international peer-reviewed selection process overseen by the three granting councils and Industry Canada. Between 1989 and 2008 the federal government invested C$ 1.3 billion in the NCE program.

Atkinson-Grosjean (2006) has documented that the evolution of the NCE program has been marked by tensions between those advocating public science as the means to research excellence and those wishing to focus research on commercial relevance. The NCE program guide (April 2010) places an emphasis on commercial relevance and highlights that: "Effective collaboration with the private and public sectors in technology, market development, and public policy development" is one criterion for program awards. (GOC, 2010n: 16).

The Mathematics of Information Technology and Complex Systems (MITACS) is one example of an NCE funded network that has evolved over time to focus on research of commercial relevance (largely through encouraging and funding U-B research collaborations). It has also expanded its activities to include delivering government funded internship programs (see text box next page).

MITACS Inc. has a 16 member board of directors. The Chairman of Board is Dr. Allen Eaves President, StemCell Technologies Inc. (a British Columbia based biotechnology company). Four other board members also have private sector affiliations. The Presidents of the University of British Columbia and the University of New Brunswick sit on MITACS' board.

As with all NCEs, the MITACS Board of Directors is accountable to the NCE Steering Committee. The NCE Program Guide provides that an NCE network must obtain the approval of the NCE Steering Committee for the initial composition of an NCE Board and that the network must advise the NCE Secretariat of any changes in membership of the Board during the course of funding. An NCE staff member has observer status on the Board of Directors of the network and also attends meetings of the network's committees. The NCE Program Guide also states that:

> "It is advisable to have some members on the Board of Directors who are not directly affiliated with the Network, and that membership includes both academic and industry representatives. The perspective of Network researchers who are not directly involved in the management of the research is also important. Therefore, the Board must have as a voting member one researcher from the Network who is not the Scientific Director or a member of any other Network committee." (GOC, 2010n: 16).

MITACS

MITACS was established in 1999 with NCE funding of C$ 14.5 million over four years (1998-2002). In 2004, MITACS received further NCE funding of C$ 37.8 million covering the year period 2005-2012. MITACS has also received funding under other federal and provincial government funding programs (e.g. C$ 10 million in 2007 from the Government of British Columbia to fund 50 graduate student internships at participating companies). Federal funding for MITACS will come to an end in 2012 and the organization is now reviewing options for making itself self-sustaining.

MITACS' objective is to build relationships with industry to transfer mathematics-based knowledge from the university to the public and private sectors (GOC, 1999: 13). In March 2002 MITACS was incorporated under the Canada Corporations Act as a not-for-profit corporation. Today's MITACS network includes 537 scientists, over 1,000 graduate students, 345 companies (60 percent of which are SMEs), 50 Canadian universities and 15 international universities. MITACS' current range of activities includes: overseeing large scale, multi-year year, and multi-partner (university-business-government) research projects in the areas of: biomedical & health; environment and natural resources; information processing; risk and finance; and communication, networks and security; operating a national cross-disciplinary internship program; and a program of industrial post-doctoral fellowships; and running MITACS International (a global network for applied mathematical sciences research).

The federal NCE program has considerably re-invigorated Canadian university research in Canada. However, notwithstanding the increasing range of U-B collaboration activities being taken up by some NCEs (such as MITACS), the program has not been without its critics. An NCE program evaluation commissioned by the federal research granting councils states that: "Globally, Restating the role of networking as a conduit to knowledge and then application is crucial. NCE networks have shown more collaboration results than application results. …There is a risk with the NCE model that networking could become an end rather than a means. (GOC, 2007a: 5).

The Business-Led Networks of Centres of Excellence (BL-NCE) program and the Centres of Excellence for Commercialization and Research (CECR) program

In 2007 the federal government established two new federal research granting programs that are explicitly designed to encourage U-B research collaboration and accelerate the commercialization of that research:[73]

- **The Business-Led Networks of Centres of Excellence (BL-NCE).** The BL-NCE program funds research networks "in strategic areas" and are, according to NSERC, run by "consortia of Canadian firms, supported by networks of academics and government researchers." (GOC, 2008c: 2-3). Also according to NSERC, the BL-NCEs differ from other Networks of Centres of Excellence because they are "shorter term, business-led, and focused on business needs." (GOC, 2008c: 2-3). Both universities and businesses are eligible to receive. BL-NCE grants under this program.[74] Universities must sign a Network Agreement

[73] The federal government also introduced a College and Community Innovation (CCI) program in 2007 that aims to increase the capacity of Canadian colleges to work with SMEs. The program received funding of C$ 48 million over five years through the federal government's 2007 budget and a further C$ 15 million through the federal 2010 budget. CCI provides funding on a competitive basis to strengthen applied research capacity, and to carry out applied research and technology transfer activities in areas where the college has recognized expertise to meet the needs of local industries, particularly SMEs. CCI includes a two-year Entry Level Grant for a maximum of C$ 100,000 per year, and a five-year CCI Grant of up to C$ 500,000 per year for the first three years, and then four-fifths of the annual base funding for the fourth and fifth years. Colleges that receive the five year grants are expected to diversify their sources of funding through increased collaboration with the private sector. All grant proposals must include a plan to involve faculty and students and an explanation of how they will work with industry partners (Association of Canadian Community Colleges, 2010: 12-13). A Private Sector Advisory Board (described later in this section) provides advice to the federal granting councils on the allocation of the CCI funds.

[74] Eligible recipients for BL-NCE funding are: Private sector networks composed of private sector enterprises with substantial Research and Development (R&D) operations in Canada, or Canadian-based private sector enterprises with the potential to benefit from R&D in Canada. The eligible networks need to (1) be incorporated as not-for-profit organizations under Part II of the Canada Corporations Act, (2) have an established Board of Directors and (3) be signatories of a Funding Agreement; and Network Members that have signed a Network Agreement and which are identified as Canadian universities, Canadian not-for-profit organizations and private sector

that is intended to permit “flexibility” in the negotiation of IP agreements between network participants. The first BL-NCE competition was launched in November 2007. In February 2009 four proposals were approved with combined funding of C$ 39.3 million. (The program’s total budget is C$ 46 million over four years).

- **Centres of Excellence for Commercialization and Research (CECR).** This program supports the operation of research and/or commercialization centres. The CECR program guide states that: “In the context of the CECR program, commercialization is defined as everything a firm does that transforms knowledge and technology into new goods, processes or services to satisfy market demands.”(GOC, 2010f: 1). Organizations eligible to receive CECR funds are not-for-profit corporations created by universities, colleges, not-for-profit research organizations, firms and other interested non-government parties. In 2007, the Government of Canada allocated C$ 285 million over five years to the CECR program. A 2010 NSERC evaluation of the CECR program drew attention to the lack of clarity in what is meant by commercialization:

> “A recurring theme throughout this evaluation relates to the lack of clarity surrounding what is meant by commercialization. … For example, the definition of commercialization used in the Program’s Funding Agreement was changed between the 2008 and 2009 competitions from a focus on manufacturing to one of transforming knowledge and technology. In addition, management from a few centres indicated that there is a need to clarify and focus program objectives relating to commercialization and research. In particular, interviewees perceive a disconnect between the Program research-related objectives and Program guidelines that limit expenditures on research-related activities. The focus of the Program needs to be evident and consistent from the selection process and criteria through to Program guidelines, and performance metrics and monitoring.” (GOC, 2010i : xiii).

The CECR are not solely concerned with commercializing university research, but according to the Private Sector Advisory Panel that advises the government on CECR awards: “Funding industry and academia research collaborations to accelerate the commercialization of leading- edge technologies, goods, and services in areas where Canada can significantly advance its global competitiveness is at the core of the CECR, BL-NCE, and CCI [College and Community Innovation] programs.” (GOC, 2009o). As of January 2011, there were 22 CECR (Table 11, next page, provides a list of the centres and their university affiliations).

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enterprises with substantial R&D operations in Canada or Canadian-based enterprises with potential to benefit from R&D. (GOC, 2009: 1).

Table 11
Centres of Excellence for Commercialization and Research

Centres	CECR Funding (C$ M)	Other Major Funding Sources (not comprehensive)	Major University Affiliations
Advanced Applied Physics Solutions Inc. (AAPS) 2008	14.95	Atomic Energy of Canada Limited; D-PACE Inc.	AAPS is a not-for-profit subsidiary of TRIUMF (Canada's National Laboratory for Particle and Nuclear Physics) headquartered at UBC.
Bioindustrial Innovation Centre 2008	14.95	Government of Ontario.	University of Western Ontario.
Canadian Digital Media Network (CDMN) 2008	10.72	Government of Ontario.	University of Waterloo
Centre for Commercialization of Regenerative Medicine (CCRM) 2010	15.00	Government of Ontario (plus 16 private sector enterprises).	University of Toronto and McMaster University.
Centre for Drug Research and Development (CDRD) 2008	14.95	Government of BC, Canadian Institutes for Health Research, Western Economic Diversification Canada.	University of British Columbia and Simon Fraser University.
Centre for Imaging Technology Commercialization and Research (CITCR) 2010	13.30	C$ 14 M committed from University of Western Ontario, the Ontario Institute for Cancer Research, Sunnybrook, Health Technology Exchange and GE.	University of Western Ontario and Sunnybrook Health Sciences Centre
Centre for Leading Operational Observations and Knowledge for the North (LOOKNorth) 2010	7.10	Not yet announced.	Not yet announced (centre to be located in the Province of Newfoundland and Labrador).
Centre for Probe Development and Commercialization (medical diagnostics) 2008	14.95	Ontario Institute for Cancer Research; various private sector sources (Pfizer, GE Healthcare, VWR International).	McMaster University.
Centre for Surgical Invention and Innovation (CSII) 2009	14.81	Government of Ontario and various private sector sources (e.g., MacDonald Dettwiler and Associates, Johnson & Johnson, GE, Phillips and Stryker).	McMaster University.
Centre for Commercialization of Research (CCR) 2008	14.95	Government of Ontario.	University of Waterloo.
Centre of Excellence for the Prevention of Organ Failure (PROOF) 2008	14.95	BC Government through the Michael Smith Foundation	UBC and affiliated research hospitals.
Centre of Excellence in Energy Efficiency (C3E) 2009	9.62	NSERC (C$ 7.7 M); private sector (e.g., Rio Tinto, Alcan, Dupont, Ericsson and Siemens).	Located at Hydro-Québec's energy technology laboratory in Shawinigan, Québec (university affiliations not available).
Centre of Excellence in Personalized Medicine (CEPMed) 2008	13.80	CIHR, Genome Québec, and C$ 3.1 M from various biotechnology companies	Université de Montréal.
GreenCentre Canada (GCC) 2008 (focusses on clean technologies)	9.10	Government of Ontario and 8 industrial sponsors	Queen 's University.
Institute for Research in Immunology and Cancer – Commercialization of Research (IRICoR) 2008	14.95	Government of Québec, Génome Québec; Bristol Myers Squibb and Sigma-Aldrich.	Université de Montréal's Institute for Research in Immunology and Cancer.
MaRS Innovation (MI) 2008)	14.95	Government of Ontario	Ontario College of Art and Design; Ryerson University; U of T.
MiQro Innovation Collaborative Centre (electronic assembly research) 2010	14.10	In the past, MiQro has received funding from the Government of Québec and Industry Canada.	MiQro founded as a partnership between Université de Sherbrooke, DALSA Semiconductor and IBM.
Ocean Networks Canada Centre for Enterprise and Engagement (ONCCEE) 2009	6.58	Multiple funding partners for Neptune Canada and VENUS ocean observatories.	ONCCEE is operated by a not-for-profit society created in 2007 by the University of Victoria.
Pan-Provincial Vaccine Enterprise (PREVENT) 2008	14.95	$10.5 M in-kind support from partner universities.	University of Saskatchewan, Dalhousie University and UBC.
Tecterra (geomatics technologies) 2009	11.69	Government of Alberta.	University of Calgary.
The Prostate Centre's Translational Research Initiative for Accelerated Discovery and Development 2009	14.95	Multiple funding partners for the sponsoring organization, the Vancouver Prostrate Centre.	University of British Columbia.
Wavefront Wireless Commercialization Centre 2010	11.60	Industry partners include: Sierra Wireless, Ericsson, Nokia, Orange.	UBC (27 other Canadian universities will be partners).

Source: Developed by the author from information on CECR web-sites.

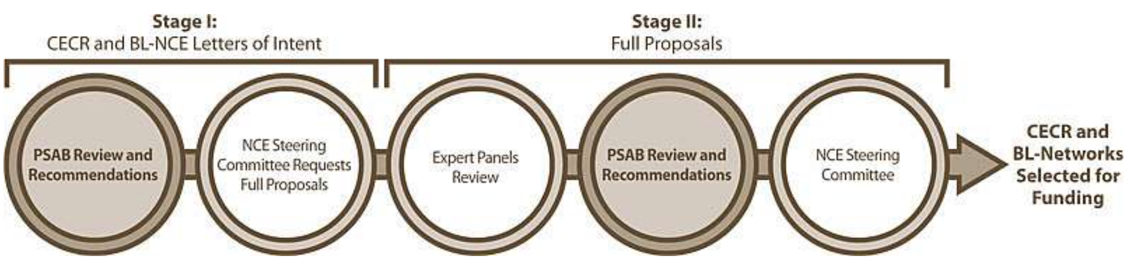
The role of the Private Sector Advisory Board

A Private Sector Advisory Board (PSAB) was created to advise the government on grants made under these programs (PSAB has no role in other national granting council programs).

PSAB has 12 members (10 permanent members and 2 alternate members). Since 2007 it has been chaired by the Honourable Perrin Beatty, a former federal cabinet minister and now Chairman and Chief Executive Officer of the Canadian Chamber of Commerce. Members are appointed by the government for a renewable term of up to two or three years. The mandate of PSAB requires them to provide recommendations on funding proposals received to a Tri-Council NCE Steering Committee made up of the presidents of three funding councils, the Deputy Minister of Industry Canada, and the President of the Canada Foundation for Innovation.

Figure 11 (below) illustrates the stage of PSAB interventions within the CECR and BL-NCE granting process.

Figure 11
Private Sector Advisory Board Role in CECR and BL-NCE Grant Award Process



Source: PSAB 2009 Impact Report (GOC, 2009o).

PSAB does not consider its mandate to include consideration of the "pure technological aspects" of research. PSAB's 2009 *Impact Report* states:

> "PSAB believes that the collective value of the group is the members' knowledge and business acumen, and the group's ability to assess the strengths, weaknesses, and opportunities of the proposals and determine the issues/risks from an implementation or exploitation perspective of the work being done, rather than the pure technological aspects of the research effort." (GOC, 2009o)

The fact that PSAB does not give great consideration to the pure technological aspects of the research effort is understandable. During the four competitions it considered between 2007 and 2009, the PSAB members evaluated more than 260 Letters of Intent and 82 full proposals (GOC, 2009o). The work load for PSAB will likely grow in the future. Grant submission rates are on the rise while grant success rates are declining around the world. Other funding agencies in the US, Europe and Asia are considering what steps they should take to ration the number of applications they receive (Van Noorden and Brumfiel, 2010).

4.4.2 Other Federal Research Funding Programs

There are many other federal institutions and programs for funding university and private sector research that have encouraging U-B collaboration as a formal objective or, at least, a major underlying premise. Four examples provided below are: the National Research Council of Canada; Automotive Partnerships Canada; the Canadian Advanced Research and Innovation Network (CANARIE); and funding programs operated through the federal government's regional development agencies.

The National Research Council (NRC)

The NRC, unlike the three federal research granting councils, conducts its own research at its own facilities. The NRC traces it origins back to 1916 and today describes itself as the Canadian government's premier organization for R&D, comprising more than 20 research institutes. The NRC reports to Parliament through the federal Minister of Industry and, in 2010, had a budget of C$ 750 million. Many of the NRC research programs and research institutes encourage U-B collaboration even though this is not always presented as their primary objective or function. Three examples are:

- **The Industrial Research and Assistance Program (IRAP)** was launched in 1962 and provides a range of technical and business-oriented advisory services, as well as financial support for small and medium-sized (SME) Canadian businesses to develop, adopt or adapt technology. Encouraging U-B research collaboration is not a stated objective or goal of IRAP, although in design and administration it does have that effect.[75] IRAP's national network of 240 Industrial Technology Advisors ITAs provide (free of charge) technical and business advice and referrals and other innovation services as needed. At least twenty percent of IRAP's Industrial Technology Advisors work out of university-based facilities (Doern and Lesvesque, 2002). Through IRAP, financial support is provided to qualified SMEs on a cost-shared basis for R&D projects that meet both the firm

[75] IRAP has two strategic goals: provide support to small and medium-sized enterprises in Canada in the development and commercialization of technologies; and collaborate in initiatives within regional and national organizations that support the development and commercialization of technologies by small and medium-sized enterprises. Lipsey and Carlaw (1998) report that: "One reason for IRAP's success… is that technology enhancement has remained its primary objective, with other objectives definitely subsidiary to it. Even where IRAP has sought to meet additional objectives, such as regional development and international competitiveness, the pitfalls associated with multiple objectives have been avoided because meeting the overriding objective — that of increasing the technical capability of industry — has been seen as the means of meeting any of the subsidiary objectives. In other words, all other objectives have been pursued in a manner consistent with the main objective." (Lipsey and Carlaw, 1998: 97).

and project assessment criteria. As early as 1966, the NRC broadened eligible costs for IRAP financial support programs to include the salary costs of university professors and researchers as an additional means of upgrading the competence of industrial teams (Lipsey and Carlaw, 1998). Today, financial support may be provided to an SME (under 500 employees) for an eligible R&D project, supporting up to 100 percent of eligible internal salary costs (technical personnel) associated with the project and up to 75 percent of eligible "contractor" fees.

- **NRC Research Institutes and Centres.** The NRC has over twenty different research institutes and centres across the country. The majority of these are co-located with, or have affiliations with, universities (e.g. the University of Alberta is a formal partner with the NRC in the National Institute for Nanotechnology located on the University of Alberta's Edmonton campus). The institutes and centres provide universities and businesses with access to their physical research infrastructure, including through a special Industry Partnerships Facilities program.

- **Community Technologies Clustering Initiative.** Starting in 2000, the NRC has provided funding (a total of C$ 343 million between 2000 and 2008) to establish and reinforce cluster initiatives (sometimes presented by the NRC as "technology clusters" and sometimes referred to as "community clusters") across the country.[76] According to the NRC: "NRC cluster initiatives work with educational institutions and the private sector to build knowledge advantage through coordinated, leading-edge R&D programs and provided access to expertise and infrastructure. The cluster initiatives drove entrepreneurial advantage by enabling industry to translate knowledge into products, processes and services." (GOC, 2009a: 8).

Funding through Automotive Partnerships Canada (APC)

APC was established in 2009 (in the midst of the automotive industry crisis) by the federal Minister of Industry to oversee an automotive research fund. The C$ 145 million fund consists entirely of financial contributions from two federal research granting councils, the National Research Council, and the Canadian Foundation for Innovation. All research projects funded through APC must have business participation and fall within one of APC's 10 research priority areas. Applications for funding are submitted by a university or college and are accompanied by an Industrial Letter of

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[76] The federal government's Budget 2010 provided additional funding to the NRC's clusters program in order to support the federal government's *Digital Strategy*: "Universities, colleges, research institutions and businesses will need to work more closely together to continue to conduct and commercialize research, moving ideas from university and college labs into the marketplace, where Canadians and the global economy can benefit from their discoveries. Recognizing this, Budget 2010 provided an additional $135 million for the National Research Council (NRC) Technology Cluster Initiatives program to develop networks of innovative businesses, NRC scientists and communities, levering Canada's investment in research into economic and social benefits for Canadians." (GOC, 2010j: 9)

Support that includes, among other items, the anticipated "interaction" of the organization's personnel with researchers from universities, colleges, and the National Research Council of Canada.

The federal government did not create an industry-led organization to review specific APC funding proposals along the lines of the Private Sector Advisory Board for certain tri-council granting programs (i.e., BL-NCE, CECR, and CIC). It did create a 16 member Industry Task Force (with 12 industry and four academic representatives) to provide "input and guidance" on defining APC's research priority areas and the roles and responsibilities of the APC Project Office.[77] The ITF has now been replaced by an Industry Advisory Committee that meets annually to review APC progress, but again the committee has no part in the review of funding proposals.[78]

Funding through the Atlantic Canada Innovation Fund (AIF) and other federal regional development programs

The federal government established the AIF (C$ 300 million) in 2001 to strengthen the economy of Atlantic Canada and "accelerate the development of knowledge-based industry." (GOC, 2010*l:* 1). The 2005 federal budget included an additional C$ 300 million for the AIF program. Administered by the federal regional development agency for Atlantic Canada, the Atlantic Canada Opportunities Agency, the request for proposals under the latest round of funding (2010) states that:

> "Partnerships in AIF projects are highly encouraged. Partnerships/collaboration between universities/colleges/other research organizations and the private sector will help to build capacity in areas of research that lead to economic growth in Atlantic Canada and will be a key determinant of the commercial success of an R&D project."(GOC, 2010*l*: 3)

Other federal government regional development agencies (Western Economic Diversification Canada, the Federal Development Agency for Northern Ontario, Canada Economic Development for Québec Regions, the Federal Economic Development Agency for Southern Ontario, and the Canadian Northern Economic Development Agency) have analogous funding programs.[79]

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[77] The ITF is co-chaired by Howard Alper, Chair of the Science, Technology and Innovation Council (STIC) and Distinguished University Professor, University of Ottawa, and Rob Wildeboer, member of STIC and Executive Chairman of Martinrea International (a Canadian automotive parts supplier).

[78] APC funding proposals are subject to the standard peer-review processes of five government funding agencies. Ten criteria are applied during peer review, including "industrial relevance.".

[79] For example, in September 2010 the Federal Economic Development Agency for Southern Ontario announced a new Technology Development Program that will provide C$ 75 million over four years to encourage collaborative research between private sector organizations and post-secondary institutions.

Funding through the Canadian Advanced Research and Innovation Network (CANARIE)

CANAIRE was incorporated in 1993 as a not-for-profit corporation with federal start-up funding of C$ 26 million. It brought under one roof academic, government and business (telecommunication companies) knowledge and interests for the provision of high speed broadband. CANARIE's initial activities were technically oriented and included the development of a high-speed experimental network for testing advanced networking technologies and applications. Today, CANARIE has 76 members from government, academia, and industry.

CANARIE's main source of funding remains the federal government (C$ 400 million since 1992). Its current five-year C$ 120 million funding agreement with Industry Canada sets out criteria that it applies when judging applications for grants it administers. For instance, CANARIE's Networked Enabled Platforms Program requires that funded projects: "…must respond to specific user needs and bring together the required players to identify requirements, create the collaborations needed and undertake the specific development activity being proposed." (CANARIE, 2009a: 19).

4.4.3 Provincial Government Funding Programs

Provincial governments and their research foundations funded C$ 1.5 billion in R&D activities in 2009 (preliminary estimates, GOC, 2009f). There are many provincial and territorial government R&D funding programs, certainly more than 50 and possibly more than 100. Examples of provincial R&D funding programs include:

- **The Government of Ontario has operated a Centres of Excellence program since 1987.** As previously described, since 2004 this program has been delivered through the not-for-profit corporation OCE Inc. Today there are six funded centres of excellence located at Ontario universities in the areas of: energy; communications and information technology; earth and environmental technologies; materials and manufacturing; photonics (there is a "cross-cutting" Centre for Commercialization of Research which also receives federal government funding support). In 2008-2009 OCE Inc. invested C$ 25.8 million in the centres and leveraged C$ 40.1 million from industry partners. (Government of Ontario, 2010: 1).

  Beginning in June 2009, the Government of Ontario began placing a number of it other funding programs for encouraging U-B research collaboration under OCE Inc. as part of its Ontario Networks of Excellence (ONE) policy framework. These programs are described by ONE in the following terms: *College Applied Research and Development* (this program supports certain collaborative projects between industry and colleges); *Collaborative Research* (designed for projects with special technical research challenges, demonstrated market pull, and high potential for commercialization); *Connections* (this service partners students in science, engineering, and other technical programs with technology-based companies); *First Job* (a salary-sharing program that supports Ontario companies who hire new graduates for R&D positions); *Institutional Proof-of-Principle* (enables public research institutions to advance research discoveries to market-ready inventions through early-stage proof-of-principle funds); *Knowledge Exchange* (promotes the exchange of knowledge and ideas between researchers and the wider economy); Market Readiness (this service aids with the initial steps of moving a promising technology from the laboratory to a new spin-off company or licensing opportunity); *Outreach Scholarship* (provides Ontario's best research students with access to world-class, expert mentorship and peer interactions outside the province—within Canada and internationally); and *Technical Problem Solving* (supports select short-term projects and collaboration between industry and academia. The goal is to build partnerships that yield commercial results and give researchers hands-on problem-solving experience. (Ontario Networks of Excellence, Web accessed February 2011).

- **The Government of Alberta's Ingenuity Centres.** In 2000 the Alberta Government established a C$ 500 million Alberta Heritage Foundation for Science and Engineering Research to fund research in Alberta. In 2001 the Foundation created the Ingenuity Centres Program, the objectives of which appear to have shifted over time. The Foundation's 2003 Triennial Report states that:

  > "The Alberta Ingenuity Research Centre program, the Fund's flagship program, offers major grants to outstanding research groups at universities and colleges working in areas of strategic importance to Alberta. These Centres give Alberta universities and colleges a competitive edge for recruiting more highly qualified researchers. Over time, the Centres will also contribute to Alberta's economic diversification and growth and quality of life." (Government of Alberta, 2002: 8).

  The Foundation's 2008-2009 Annual Report states that:

  > "The [Ingenuity] Centres program supports industry, government and academic collaborations that expedite the path for technologies to reach market." (Government of Alberta, 2002: 8; and 2009: 6).

  In late 2009, all Alberta government research funding agencies and programs, including the Heritage Foundation for Science and Engineering Research and its Ingenuity Fund and Ingenuity Centres Program, became part of a new Alberta government organization, *Alberta Innovates - Technology Futures*). Since 2001, seven Ingenuity Centres have been established (see Table 12 next page). Many of the centres have received funding from both the Government of Alberta and the federal government.

Table 12
Alberta Ingenuity Centres for Research and Commercialization

Alberta Ingenuity Centre and University Affiliation	Funding (illustrative not comprehensive)	Company Participation
Centre for Machine Learning - University of Alberta.	C$ 11.8 million from the Government of Alberta; C$ 50.0 million leveraged funding.	EzSeer, Google, Myriad Machine Learning, IBM, Redengine
Centre for Carbohydrate Science - University of Alberta.	C$ 12.2 million from the Government of Alberta, plus federal funding; $ 50.0 million leveraged funding.	TheraCarb, Wellstat, Amgen
Centre for Oil Sands Innovation - University of Alberta.	C$ 2.4 million from the Government of Alberta, plus federal funding (two NSERC industrial research chairs which are linked to COSI's research on oil sands); C$ 50.0 million leveraged funding.	Imperial Oil, StatOil, TOTAL, Shell, Repsol Energy Canada, Nexen, Conoco Philips, Gushor Inc., and Profero Inc.
Centre for In Situ Energy - University of Calgary.	C$ 7.9 million Government of Alberta, plus federal funding through the Canada Foundation for Innovation;	
Tecterra Inc. (also a federal CECR) - University of Calgary.	C$ 21.5 million from the Government of Alberta; C$ 11.7 million from federal government.	Industry partnerships under development.
Centre for Integrated Biomedical Technologies - University of Calgary.	C$ 7.4 million from the Government of Alberta plus federal funding.	BOSE Electroforce Systems Group, Calgary Scientific, Siemens, IMRIS
Centre for Clean Coal /Carbon and Mineral Processing Technology - University of Alberta.	C$ 21 million from the Government of Alberta, plus contributions from private sector.	Hatch, Capital Power Corporation, Teck, Nexen, and Foundation CMG

Source: Assembled by the author from information contained in: *Alberta Ingenuity Annual Report 2008-2009*; and *Alberta Innovates - Technology Futures Annual Report 2009-2010*; and Ingenuity Centre websites.

Provincial Government Voucher Programs

Over the past three years the Governments of Nova Scotia, Alberta, and Newfoundland and Labrador have introduced voucher programs to encourage U-B collaboration. The Government of Québec's 2010 innovation strategy provides for the introduction of "incubation vouchers" in that province. These voucher programs subsidize the purchase of services and expertise by small and medium sized businesses from eligible provides – typically the higher education sector but in some cases (Alberta and Newfoundland) other third-party suppliers. The Nova Scotia voucher program has been oversubscribed in each and every year since it was introduced in 2008 (in its first year, 50 vouchers were issued although 183 applications were received).

In 2010 the Government of Alberta opened up its voucher program (on a pilot basis) through a reciprocal voucher program with the Bavarian State Government in Germany (Government of Alberta, 2010a). The Government of Newfoundland and Labrador's voucher program (managed by the government's Research and Development Corporation (RDC)) was launched in 2010 and has been open to international voucher redemption from the beginning. In 2010, RDC received 12 voucher applications and issued 10 vouchers. Two of these vouchers were for the purchase of specialized services from providers in Israel and the US. Table 13 (below) summarizes the different features of the three programs.

Table 13
Canadian Provincial Government Voucher Programs

	Nova Scotia	Alberta	Newfoundland and Labrador
Total voucher program budget	C$ 500,000 ('08-09)	$ 10 million ('08-09)	C$ 125 thousand (2010).
Number of companies	50 ('08-'09)	180 ('09-'10)	10 (2010)
Eligible service providers	Designated higher education institutions in Nova Scotia.	Alberta higher education institutions, and other designated third parties.	Designated service providers, including higher education institutions in the province.
Eligible businesses	Small and medium-sized businesses (less than 100 employees). No sectoral conditions apply.	SMEs (less than C$ 5 million in gross revenues & fewer than 51 employees; be active in agriculture, forestry, energy, environment and health; & carry on majority of business activity in Alberta.	Innovative SMEs located in the province of Newfoundland and Labrador with early stage R&D needs and high growth potential.
Value of vouchers	Maximum value of C$ 15,000 and up to 75 percent of eligible project costs.	Up to C$ 15,000 (for Opportunity Assessment and up to C$ 50,000 for more substantial technology development activities	Maximum value of C$ 15,000 and up to 75 percent of eligible project costs.
International Openness	Vouchers currently redeemable only through Nova Scotian service providers.	Pilot project underway to permit voucher redemption through foreign service providers.	Vouchers can be redeemed through foreign service providers (subject to RDC pre-approval.

Source: Information assembled by the author from provincial government voucher program guides and through discussions with provincial government officials.

4.4.3 Other Fiscal Incentives

This section describes how Canadian governments are employing R&D tax credits (in the case of the federal government, Ontario and Québec), tax measures relating to intellectual property (in the case of Ontario), and public procurement (in the case of federal government defence procurement) to encourage U-B research collaboration.

4.4.3.1 The Federal Scientific Research and Experimental Development (SR&ED) Tax Credit

At the federal government level the SR&ED tax credit was first introduced in 1977 and has been subject to continuous revision thereafter (Madore, 2006). Table 14 (below) compares features of the Canadian federal SR&ED tax credit with those of the US federal Research and Experimentation tax credit as of June 2009.

Table 14
Features of the SR&ED Tax Credit in Canada and the US Federal Research and Experimentation Tax Credit as of June 2009

CANADA	UNITED STATES
- 20% federal tax credit for all SR&ED expenditures (provincial SR&ED tax credits also available in all provinces except Prince Edward Island).	- 20% federal tax credit for incremental R&E. (State R&E tax credits also available in certain states).
- 35% refundable SR&ED tax credit available to certain Canadian Controlled Private Corporations.	- No refundable R&E tax credit.
- Canadian SR&ED credit definition broader than U.S. R&E definition.	- U.S. definition of R&E is more restrictive than Canadian SR&ED definition.
- Qualifying SR&ED expenses include salary and wages, materials, contract payments, leases, overheads, and capital expenditures.	- Qualifying R&E expenses include salary and wages, supplies and contract expenses.
- No restriction on eligible SR&ED contracts (100% of amount to be claimed).	- Eligible R&E contracts restricted to 65% of contract amount.
- 100% write-off for eligible SR&ED equipment.	- No accelerated write-off for R&E equipment.
- Unused SR&ED tax credits can be carried back 3 taxation years and forward 20 taxation years.	- Unused R&E tax credits can be carried back 1 taxation year and forward 20 taxation years.
- SR&ED tax credit is permanent.	- R&E credit is extended every few years. It has not yet been made permanent..

Source: PriceWaterhouseCoopers Canada (2009).

The future of the federal SR&ED tax credit is now one of the subjects of study by a federal expert panel that is reviewing federal support for business and commercially-oriented R&D. The Panel has stated that it has been asked to provide advice related to three questions, one of which is: "Is the **current mix** and design of tax incentives and direct support for business R&D and business focused R&D appropriate?" (GOC, 2010m: 3). [emphasis added] [80]

It is beyond the scope of this report to consider the broad issue of whether some portion of federal government support for business R&D should be moved away from the tax system to program spending (although, should greater reliance be placed on direct program spending, then a range of new policy options may open up for how these programs can be designed and administered to encourage U-B collaboration). However, it is relevant for this report to consider whether or not the federal government should enrich or re-design the SR&ED tax credit program specifically to stimulate business investment in university research or continue to place reliance on direct program spending. Based on the Canadian policy experience in the past and today, there are at least three factual circumstances and four main policy considerations to bear in mind.

Factual Circumstances

1. **The SR&ED tax credit is the largest program of federal support for business R&D, far exceeding all direct spending programs to support business R&D.** The Council of Canadian Academies (2009a) has reported that:

> "Canada's total government support for business R&D (tax and direct spending combined) is somewhat larger, relative to GDP, than that of the United States and the United Kingdom. It is noteworthy that Canada's heavy reliance on the tax assistance channel makes it virtually an outlier… This invites close analysis as to why Canada has chosen such an extreme

[80] The Panel has stated that the other two questions are: "What federal initiatives are most effective in increasing business R&D and facilitating commercially relevant R&D partnerships' and what, if any, gaps are evident in the current suite of programming, and what might be done to fill these gaps? In addition, the Panel's mandate specifies that its recommendations not result in an increase or decrease to the overall level of funding required for federal R&D initiatives. The formal public mandate for the panel is that: "The Panel has been asked to review three types of federal R&D initiatives: Tax incentive programs such as the Scientific Research and Experimental Development (SR&ED) program; Programs that support innovative business R&D, including: (1) general support (e.g., the Industrial Research Assistance Program); (2) sector support(e.g., the Strategic Aerospace and Defence Initiative); and (3) regional support (e.g., the Atlantic Innovation Fund); Programs that support business-focused R&D through federal granting councils and other departments and agencies, including basic research performed in universities and colleges that fosters support to business R&D (e.g., the Centres of Excellence for Commercialization and Research). The Panel will also have the latitude to consider other federal initiatives relevant to the Review's scope. However, the Review will not include research conducted in federal laboratories to fulfill their regulatory mandates or basic research conducted in institutions of higher education that is not intended to foster support to business R&D." ((GOC, 2010m: 3).

> mix of assistance delivery mechanisms and whether such a tax-heavy emphasis is appropriate." (CCA, 2009a: 161). [81]

Total tax expenditures under the SR&ED tax credit are projected by the Canadian Department of Finance to be C$ 3.3 billion in 2009 and C$ 3.5 billion in 2010 (GOC, 2009n: 24 and GOC, 2011a: 21). The 2009 projection for SR&ED tax expenditures represents: 58 percent of the C$ 5.7 billion in total federal funding of R&D performed in all sectors in 2009; 23 percent of total business expenditures on R&D (funded from all sources) of C$ 14.2 billion in 2009; and 11 percent of total federal corporate tax revenues of C$ 29.5 billion in 2008-2009;[82]

2. **The SR&ED tax credit has never been portrayed by the federal government as having encouraging U-B research collaboration as its primary objective. However, in both design and administration the federal SR&ED tax credit takes account of business investment in university research.** A joint evaluation of the federal income tax incentives for scientific research and experimental development prepared by the Department of Finance and Revenue Canada in 1997 states that:

> "The basic structure of the current federal system of income tax incentives for SR&ED was put in place between 1983 and 1985. The policy objectives underlying these incentives were also introduced in 1983. While adjustments have been made to the SR&ED tax incentives since 1983, the policy objectives have not changed. These objectives are to:
>
> – encourage SR&ED to be performed in Canada by the private sector through broadly based support;
>
> – assist small businesses to perform SR&ED;
>
> – provide incentives that are, as much as possible, of immediate benefit;
>
> – provide incentives that are as simple to understand and comply with and as certain in application as possible; and

[81]The OECD reported in December 2010 that: "More countries are using tax incentives than a decade ago and the schemes are more generous than ever. Today, more than 20 OECD governments provide fiscal incentives to encourage business R&D, up from 12 in 1995 and 18 in 2004. Among those that do not, Germany and Finland are currently discussing their introduction." (OECD, 2010c: 4).

[82] As a further point of comparison, the estimated revenue foregone under the US federal government's Research and Experimentation tax credit was US $7.3 billion in fiscal year 2006, the latest year for which data is available. This amount is: 7.4 percent of US federal funding of R&D (performed in all sectors) of US$ 98 billion in 2006; 3.3 percent of total industry funded R&D in 2006 (USG, 2010s:C4-31); and 1.9 percent of total federal corporate incomes collected (US$ 380.9 billion in 2006).

– promote SR&ED that conforms to sound business practices.” (GOC, 1997: vi).

However, the definition of work that qualifies for the tax credit is sufficiently broad to include what is commonly undertaken in U-B research collaboration (including basic research). Moreover, from time to time the program has been adjusted to take account of (and presumably increase the impact of) federal grant programs that directly or indirectly support U-B research collaboration. For example, the Canada Revenue Agency (CRA) has sought to identify payments made by third parties (i.e. businesses) in support of university research chairs that may be allocated to SR&ED eligible research activities. The CRA has also issued a blanket policy that permits all third party payments to support NSERC’s Industrial Research Chairs as being potentially eligible for the SR&ED tax credit (subject to all the other SR&ED program conditions (GOC, 1999).

3. **Little is known about the impact of the existing SR&ED tax credit on U-B research collaboration.** The Canada Revenue Agency and the Department of Finance do not release public information on SR&ED tax credits earned or claimed for research expenditures incurred through third-party research (in general or through universities).[83] Many of the major government and academic studies of the SR&ED tax credit have focused on two questions: whether or not the credit has incented business to invest more in R&D than would otherwise have been the case (i.e., incrementality); and how generous Canada’s R&D tax credit is relative to R&D tax credit programs found in other jurisdictions.

Four policy considerations

- **Over the past quarter century a number of proposals have been advanced to use the Canadian tax system to encourage U-B research collaboration but**

[83] For the purposes of administering the SR&ED tax credit, the CRA makes a distinction between “third-party research” and “contract research” based on the degree of control exercised by the payer on the results of the SR&ED. In general, third-party research (which refers to circumstances where the payer has rights to the results of the research while the performer has control over the activities) is the most germane to U-B research collaboration. Third-party payments may be made to “Approved universities, colleges, research institutes, or similar institutions.” In contrast, while contract research may involve universities, it may also include a wide variety of other individuals and companies. The definition of “contract research” for the purposes of administering the SR&ED tax credit is different from that employed Statistics Canada in its *Survey of Intellectual Property Commercialization in the Higher Education Sector* in which “Research contracts” are defined as “arrangements under which the educational institution, or an individual within the institution, agrees to undertake a research project on a specified problem, using the institution's facilities and/or personnel, for a sponsor that provides funds to meet all or part of the costs of the project.” (GOC, 2008d: 4). The implication is that the available Statistics Canada data on higher education research contracts may not be the best source of data to draw upon when judging the impact of the SR&ED tax credit on research conducted through third-party payments by business to universities.

they have not been acted upon by the federal government. For example, in 1985 the Royal Commission on the Economic Union and Development Prospects for Canada (1985) stated that:

> "A number of observers have noted the lack of business support for university research in Canada. Some have suggested extension of R&D tax incentives to apply to contributions made by firms in support of university R&D. Given probably substantial national benefits from this type of research, it would seem a candidate for preferential tax credit." (GOC, 1985: VII, 102)

But the Commission's final recommendation on the use of the tax system to encourage business R&D was not specifically aimed at encouraging business investment in university research. Instead, the Commission made the general recommendation that the federal government should: "Broaden the definition of R&D while lowering the rate of tax subsidy, even though we recognize that such a broadening could give rises to administrative problems." (GOC, 1985: VII, 382).

In 2006, the Conference Board of Canada recommended that the federal government should:

> "Provide tax incentives to businesses collaborating with university researchers. In addition to providing matching funds for research, the federal government could provide tax credits to businesses that invest in collaborative research projects with universities. Incentives could be variable based on the levels of investment (to encourage business spending on research and development) or on the number of consecutive years of collaboration (to encourage the deepening of relationships)." (Conference Board of Canada, 2006: 25).

The federal government has not taken up the Royal Commission's recommendation (i.e., it has not "lowered the rate of tax subsidy" although it has made continual adjustments to program definitions and eligibility requirements) or the more specific recommendation made by the Conference Board of Canada.

- **Re-designing the SR&ED tax credit specifically to encourage U-B research collaboration carries some risk of decreasing the level of business investment in their internal R&D activities.** As previously mentioned in section 2.4.4 of this report, one empirical study of the US experience with state-level R&D tax credits in Massachusetts and California (Paff and Watkins, 2009) found that changes in the composition of firms' R&D budgets between in-house R&D and external basic research may be attributed to changes in R&D tax incentives. They find that, on average, the sample of firms considered shifted away from in house R&D when faced with lower relative prices of external contract research. This is only a single study and the findings should be treated with due caution.

Nonetheless, it does underline that the law of unintended consequences may apply when seeking to use general R&D tax credits for specific purposes, in this case encouraging U-B research collaboration.

- **Moving from reliance on the tax system to support business R&D and transferring the freed-up resources to direct support for business R&D, has been tried in the past and found to be wanting – but the right lessons should be drawn from this policy experience (including from the viewpoint of seeking to encourage U-B research collaboration).** In 1968 a provision of the Canadian tax system that provided a tax deduction (not a credit) for business R&D was eliminated by the federal government and replaced by a new system of program support under the *Industrial and Regional Development Incentives Act* (IRDIA). The then federal Minister of Industry, the Honourable C.M. (Bud) Drury, told the House of Commons upon 2nd reading of the legislation that:

> "Since 1962 the Income Tax Act has provided an incentive… whereby companies have been able to deduct from their income an additional allowance of 50 percent of the amount by which their expenditures on scientific research exceeded their total expenditures for this purposes in the 1961 base year. …However, a number of problems and shortcomings in its operation have become apparent which is evidenced by the fact that in 1963 only 265 out of a total of some 600 firms performing research and development were able to claim benefits under the additional allowance. The proposed legislation [Bill C-252 – to provide grants to corporations for research and development] is designed to overcome these deficiencies.
>
> In the first place, the use of the income tax laws as a vehicle for subsidizing research and development effort is essentially discriminatory since eligibility depends on the firm's tax position. Under these circumstances, many small or growing firms which are not yet in a profit-making position, but which perhaps have the greater need for research and development assistance, are excluded. Hence, in order to broaden the availability of the general incentive and in the interests of equity, it is proposed to remove it from the Income Tax Act and to provide a system of statutory grants, or credits against tax liabilities if firms so choose, for which all firms could qualify. Further, unlike a tax allowance, the cost of a grant system is readily apparent and can be accounted for to parliament in the same way as other expenditures." (GOC, 1966: 11433)

Under the IRDIA program, 2,412 grants were issued to companies totaling C$ 290 million.[84] The IRDIA was implemented and administered by the federal Department of Industry. The IRDIA was repealed in 1975 (although grant money continued to flow for some years). In 1977 an SR&ED tax credit was

[84] This is the amount cited in Madore (2006: 5). However, Lipsey and Carlow (1998) cite a lower figure, C$ 57 million based on data contained in Department of Industry Annual Reports between 1970-1971 and 1977-1978.

introduced which ranged from 5 percent to 10 percent of current and capital expenditures, depending on the size of firm and region in Canada where activities were carried out (Madore, 2006). The two main reasons for why the IRDIA was abandoned were: its administrative complexity; and that it became an easy target for federal fiscal restraints imposed as a response to stagflation in the mid-1970s. Lipsey and Carlaw (1998) have described the IRDIA's administrative complexity as follows:

> "The [IRDIA grant] application had to be submitted within six months after the end of the applicant's fiscal year in which the R&D took place. A mass of detailed information was required, including a commercial and technical description of the applicant's business, markets and sales, a minute description of its R&D facilities, and a description of R&D projects and programs briefly explaining the goals, methodology and results… The applications also required a mass of financial and administrative detail about the projects to be supported.... Any support for R&D coming from other sources had to be reported. All assets acquired for R&D through capital expenditures during the grant's year date had to be listed and any subsequent disposal reported." (Lipsey and Carlaw, 1998: 56)

The right lessons should be drawn from this experiment in moving resources from the tax system to direct program spending to support business R&D. Yes the IRDIA was a failure, but perhaps it was a failure in program design and administration as much as in fundamental concept (after all, an equally bad experience in the design of tax incentives to encourage R&D occurred with the introduction of the short-lived federal Scientific Tax Credit in 1983).

- **The fundamental considerations for choosing between using the tax system and direct program spending to encourage U-B collaboration are much the same as when making the same choice in other areas of public policy.** Canadian economists Richard Lipsey and Kenneth Carlaw (1998) have suggested that tax incentives may be most effective as framework policies that provide general support for specific activities across the entire economy and that do not discriminate between firms, industries or technologies. Direct program spending may be most effective where market failures are large and concentrated in localized situations.

Based on these factual circumstances and broad policy considerations, and to foreshadow one of the conclusions of this report, it is likely that:

- tinkering with the existing SR&ED tax credit in an effort to encourage U-B research collaboration (e.g., through implementing the Conference Board of Canada recommendation) is likely to be less important and less effective than ensuring that direct spending programs to encourage U-B collaboration are well designed and delivered; and

- should a decision be taken (one based on considerations much wider than encouraging U-B collaboration and upon which this report passes no judgement) to move some portion of support for business R&D away from the tax system to program spending, then a range of new policy options may open up for how those programs can be designed and administered to encourage U-B collaboration. On this subject, there are institutional models and lessons to be drawn from the Canadian experience and from foreign jurisdictions. Examples referred to in other sections of this report include: OCE Inc. in the province of Ontario (section 4.3.1.1); the UK Technology Strategy Board (section 6.4.2); and Commercialisation Australia (section 7.3.1.2).

4.4.3.2 Québec and Ontario Government R&D Tax Credits to Encourage U-B Collaboration

Apart from the general R&D tax credits, two provinces, Québec and Ontario, have introduced special tax credits (in addition to their general R&D tax credits) to encourage U-B research collaboration.

- **The Government of Québec** offers a refundable tax credit for university research or research carried out by a public research centre or a research consortium. Access to this tax credit requires pre-authorization (adjustments to improve the pre-authorization process were contained in the 2010 provincial budget). According to the Québec Ministry of Revenue:

  > "Taxpayers that enter into a university research contract with an eligible university entity, public research centre or research consortium may claim a refundable tax credit of 35% of qualified R&D expenditures. If the research is conducted by an eligible university entity, public research centre or research consortium dealing at arm's length with the taxpayer, the credit is calculated on 80% of qualified expenditures (20% of the value of the contract being attributed to profits)." (Government of Québec, 2009: 13)

  Tax expenditures under the Québec Government's university research tax credit were in the range of between six and eight million dollars annually over the 1997 to 2005 period. In comparison, estimates of tax expenditures under the Québec Government's general R&D refundable tax credit tax credit for salaries and wages of researchers ranged between C$ 319 million and C$ 566 million annually over the same period (Baghana and Mohnen, 2009).

- **The Government of Ontario** offers a refundable Ontario Business-Research Institute (OBRI) Tax Credit. It provides eligible corporations with a 20 per cent refundable tax credit for scientific research and experimental development expenditures incurred in Ontario under an eligible contract with an eligible research institute (ERI). There is an annual C$ 20 million cap on qualifying

> expenditures and the maximum tax credit a corporation or an associated group of corporations can claim is C$ 4 million. Small businesses may claim the 20 percent tax credit in addition to the 10 percent Ontario Innovation Tax Credit for a combined tax credit of 30 per cent of qualifying expenditures. Estimated tax expenditures under the OBRI were C$ 8 million in 2009. In comparison, tax expenditures under the non-refundable Ontario Research and Development Tax Credit were C$ 200 million in 2009 and C$ 195 million in 2010 (Government of Ontario, 2009b and 2010b).

Government of Ontario Tax Exemption for Commercialization Program (OTEC)

The objective of this program, announced in 2008 and introduced in 2009, is to encourage commercialization of intellectual property which is developed by qualifying Canadian universities and colleges (Government of Ontario, 2008a).[85] The OTEC program is available to newly established corporations (incorporated between March 2008 and March 2012) operating a business in the areas of: advanced health technologies; "bio-economy"; or certain telecommunications, computer or digital technologies. It offers them an exemption from Ontario's corporate income tax and corporate minimum tax for ten years. A variety of eligibility conditions apply, including that the intellectual property must have been developed during the course of employment or academic study at a qualifying institute, which includes a university in Ontario, a college of applied arts and technology in Ontario, and eligible Canadian universities and colleges located outside Ontario (Government of Ontario, 2009a: 3) Estimated revenue foregone under this program have not yet been published.

4.4.3.3 Federal Government Defence Procurement

Canada's Industrial and Regional Benefits (IRB) policy uses federal defence procurement to strengthen industrial and regional development. Bidders are generally required to identify benefit plans to achieve benefits equal to 100 percent of contract value and to identify regional, small business, and aboriginal business benefits where appropriate.

In 2009 a revised IRB policy was announced by Industry Canada, including a new incentive to encourage the creation of private-public consortia involving a prime contractor, one or more publicly or privately owned Canadian companies, and a minimum of one post-secondary or not for profit research and development institution. The new incentive awards an IRB credit towards meeting IRB commitments. Industry Canada's policy rationale for the new incentive is:

> "The increased use of private-public consortia is attractive as a means for Canadian industry to participate in leading-edge research and development, while maintaining a reasonable cost structure. Industry Canada recognises the

[85] In 2008 the Government of Ontario invited the federal government to match the ten-year corporate income tax exemption, but this invitation was not taken up. (Government of Ontario, 2008a: 132).

> importance that these consortia may play in developing next generation technologies and services that are led by industry and supported by Government and academia. It is hoped that this change will significantly incent business-led innovation activities between global multinationals, Canadian industry, academia and the public research institutions."(GOC, 2009h).

The federal government announced in June 2010 that the first consortium eligible for the new incentive is the Canadian Composites Manufacturing Research and Development consortium (CCMRD). This consortium is led by the Composites Innovation Centre in Winnipeg, the National Research Council Canada, and Boeing Canada as the Prime Contractor.[86] According to the federal Minister of State for Western Economic Diversification:

> "Boeing's investment into the CCMRD is the first use of the IRB policy change to provide an incentive for the creation of Public-Private Consortia. This policy initiative is designed to encourage industry-government-academia consortia to develop next-generation technologies and services in aerospace, defence and related sectors. The investment into the CCMRD is an excellent example of not only our IRB policy at work, but of the new improvements to the policy." (GOC, 2010e).

It remains to be seen, and may prove difficult to quantify, what additional research dollars may flow for aerospace R&D performed at Canadian universities than would have occurred in any event. The larger companies in the sector already have strong research linkages with the university aerospace and engineering research community and with the NRC's aerospace technology centres.[87] Perhaps the new incentive has much to do with positioning small and medium sized aerospace manufacturers to participate in future competitively awarded sub-contracts flowing from large scale aerospace and other defence procurements (i.e., within global supply chain procurement arrangements for the F-35 Joint Strike Fighter program) as it may have to do with encouraging Canadian U-B collaboration in the aerospace sector.

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[86] Other founding members include: Bell Helicopter and Avior Integrated Products in Québec; Comtek Advanced Structures in Ontario; Convergent Manufacturing Technologies and Profile Composites in British Columbia; and Bristol Aerospace in Manitoba.

[87] Pratt and Whitney Canada's corporate website (www.pwc.ca) states that the company funds over 250 research projects with some 20 Canadian universities and the National Research Council and that it "spearheaded" the creation of four university aerospace institutes. Another example of U-B collaboration in the aerospace sector is the Vancouver Institute for Visual Analytics (VIVA), launched in April 2010 by Simon Fraser University and the University of British Columbia with a C$ 1.25-million investment from Boeing Canada.

4.5 Canadian Governments as Rule-makers

Earlier in this report (section 3.1) it was suggested that there are two features of government rule-making to encourage U-B collaboration that distinguish them from the much larger universe of government rule-making activity:

- they are intended to achieve any number of broader policy objectives, but encouraging U-B collaboration is one of their *foreseen* consequences; and,

- they may have a diffuse impact on U-B collaboration but nonetheless have a significant and *foreseen* influence on economic incentives for U-B collaboration.

Examples of Canadian government rule-making to encourage U-B collaboration are presented here in three areas: intellectual property[88] rules relating to federal research grant awards; federal intellectual property rule-making activity in the patented medicines sector and its impact on the investment climate for U-B research collaboration; and federal government rule-making in the area of direct foreign investment.[89]

4.5.1 Intellectual Property (IP) and Federal Research Council Grants

Over the past two years the general direction of the federal government's research granting councils has been to give universities greater flexibility and choice in how they design their IP policies and management processes in relation to the receipt of granting council research funding. Yet it is the very diversity in IP policies and processes at universities which is seen by some observers as an obstacle to U-B collaboration. Robert Prichard, President Emeritus of the University of Toronto and member of the federal government's Science, Technology and Innovation Council, has stated:

> "We need a dramatic national statement attached to federal research support that would see us have a standardized, easy and extremely open regime to encourage

[88] The Conference Board of Canada's 2010 report *Intellectual Property in the Twenty-First Century* underlines that: "Intellectual property rights are just one form of stimulus for innovation, not the sole guarantor of Canada's innovation ranking and economic competitiveness. They should not be permitted to become the whipping boy for debate. Policy analysis should always consider them in combination with other stimuli to innovation." (Conference Board of Canada, 2010: iii). The Conference Board report makes a number of recommendations to improve business governance of intellectual property and to "vision, leadership, and effective coordination at the national level." The report does not discuss IP negotiation or management issues as they occur within university settings.

[89] There are other areas worthy of research in the future, including: the importance of government rule-making in the area research integrity and research ethics and how that impacts on the environment for U-B research collaboration; and provincial government policies respecting the structure and governance of their higher education sectors.

> the interplay between the academic research sector and the commercial sector." (Prichard, 2010: 4)

NSERC'S 2001 IP policy prohibited the assignment to a third party of IP arising from an NSERC award. At that time, the policy reflected a concern that in some cases the assignment of IP ownership to third parties could result in lost benefit to Canadian taxpayers. A 1999 report from an advisory panel to the Prime Minister's Advisory Council on Science and Technology reflected this concern when it stated:

> "While many of the university researchers that do commercialize their IP generate benefits to the nation, it is not reasonable to assume that they all act in the national interest. The Panel is aware of many cases where Canadian researchers created IP with public funds, entered into consulting contracts with U.S. firms, and were handsomely rewarded through consulting fees in return for assigning away IP rights. This is how Canada lost the jobs and investments that it was entitled to expect from its investment in therapeutics research. Although most of the research was funded by Canada, all manufacturing and value added from this global industry is taking place outside the country." (GOC, 1999a: 20-21).

In 2009 NSERC commissioned an expert panel to undertake an extensive review of its 2001 IP policy. NSERC explained that:

> "In recent years… concerns have been raised that the lack of assignment of ownership of patent rights may act as a barrier to effective commercialization and exploitation of the research results and hence limit its potential impact. This may be particularly true for start-up companies wherein their ability to secure patent ownership rights may directly affect their capacity to attract investment. It may also be problematic for an established industrial partner since, depending on the country, the rights of a licensee may be very restricted compared to those of an owner. …While various universities have indicated that the policy established in 2001 has been very effective as a baseline in their negotiations with companies, in many other instances universities appear to perceive it as a deterrent and would prefer to negotiate IP ownership depending on the nature of the proposed research, the involvement of the company and the expected benefits." (GOC, 2009i: 1)

The expert panel (comprised of government, industry and university representatives) conducted a survey of 216 individuals with an informed view on IP issues. The panel reported that, of the175 responses received:

- 50 percent saw the prevention of assignment of ownership as a significant or very significant barrier to establishing a university-industry collaboration and to commercializing the results;

- seven percent were in favour of NSERC continuing to prohibit the assignment of patents by universities through conditions it attached to its research funding;

- 38 percent (predominantly from industry) felt that assignment should be permitted; while 55 percent (predominantly from industry) felt that assignment should be permitted but only under certain conditions; and,

- there was little support for assignment to foreign companies with no significant presence in Canada. (GOC, 2009k: 2-3).

The expert panel recommended to NSERC's Governing Council that NSERC's IP policy be revised to increase flexibility on the assignment of ownership by universities while also ensuring adherence to a series of principles, including "research results should be exploited for the maximum benefit to Canada."(GOC, 2009k: 3).

To digress for a moment, and also to foreshadow a discussion later in this report on UK IP policy directions (section 6.4.3), it is notable that the UK is not relying on "principles" to prevent movement of IP offshore (whether originating or owned by universities or others). It is planning on using fiscal incentives. In November 2010 the UK Treasury embarked on a consultation process with their business sectors on the taxation of IP in order to prevent the movement of IP offshore. The UK consultation paper states: "The Government believes that it is right to introduce this reform [to the taxation of IP] now in order to prevent movement of IP offshore and encourage the development of new patents by UK businesses, protecting and enhancing the status of the UK as a world leader in this field." (HMG, 2010*l*: 51).

Returning to the subject of NSERC's IP policy, NSERC's Governing Council issued a revised IP policy in March 2009, with the major change being the removal of the prohibition on grant recipients assigning IP (arising from NSERC grants) to third parties. In effect, NSERC increased the flexibility of universities to determine their own IP policies and processes.[90]

NSERC reports that it has met with representatives from the other two Canadian federal granting councils to discuss the possibility of developing a harmonized Tri-Council intellectual property policy and that:

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[90] Other features of the new NSERC IP policy include: principles (e.g. "Promote the development of fruitful and productive partnerships and recognize the unique contribution each partner brings to the partnership and the need for each partner to benefit from the relationship and have their interests protected" and "Support the publication of research results in the open literature. NSERC does not support secret or classified research."); mandatory elements in all IP agreements arising from and related to an NSERC award (e.g. agreements where access to IP is granted via an exclusive license or assignment must state that exploitation will be pursued with due diligence and within an appropriate time frame; and the results of the research must be publishable in the open literature); and, a series of "additional considerations" (e.g. when an IP Agreement is a mandatory prerequisite for an NSERC award it may be reviewed by NSERC to ensure that it includes mandatory elements. NSERC may withdraw the offer of award should the finalization of the IP Agreement be unduly delayed).

> "While those Councils are interested in such an approach and are willing to pursue this in the future, it is recognized that significant work will have to be done to consult their representative communities and to ensure that issues specific to their communities are identified and properly addressed in a Tri-Council Policy." (NSERC, Web, Accessed January 2011).

Some Canadian provincial governments are giving attention IP issues within the context of university-business research collaboration. For example:

- **The Government of British Columbia's Technology Council** reported in June 2010 that its public consultations on building U-B partnerships found that "IP policy" is an obstacle to U-B collaboration:

  > "Industry participants believed it was too complicated and cumbersome and there was additional complexity because the institutions had different policies. They were looking for a process that was clear and simple and preferably industry friendly. There was also some discussion around whether IP Policy should be more standardised across the board, or whether it should be more flexible to adjust to each individual case. In contrast, representatives from the universities posited that IP Policy was only perceived as an obstacle, and that better policies around relationships between industry and academia could ameliorate whatever challenge IP poses. Nevertheless, there was not a great deal of satisfaction with IP policy as it currently stands." (Government of British Columbia, 2010: 20).

- **The Government of Nova Scotia's 2010 review of its university system** appeared less critical of the existing IP management processes at Nova Scotia's universities:

  > "From an internal university policy perspective, there has been ongoing debate on whether the researcher owned IP policy in place here in Nova Scotia and in a majority of Canadian post-secondary institutions is the right approach to encourage technology/knowledge transfer and increased commercialization activity and results. It could be argued that the current disclosure and transfer provisions contained in Nova Scotian university faculty agreements essentially have created a hybrid researcher-owned/institutionally owned IP environment. The establishment of ILO [Industrial Liaison Office] operations in Atlantic Canadian universities and the creation of Springboard Atlantic were an attempt to add the necessary facilitation and support to help the existing system work better."(Government of Nova Scotia, 2010b: 147).

- **The 2009 annual report of the Auditor General of Ontario recommended that:**

> "To better promote the commercialization of research done at Ontario's publicly funded research institutions and ensure that the social and economic benefits of the research are retained in Ontario, the Ministry of Research and Innovation should continue to review best practices for intellectual property management in other jurisdictions and, on the basis of the best practices identified, implement consistent guidelines for the management of intellectual property across Ontario's publicly funded research institutions. (Government of Ontario, 2009c: 243).

In response, the Government of Ontario's Ministry of Research and Innovation stated that:

> "The most effective approach to managing intellectual property (IP) remains an ongoing topic of debate within the research community across Ontario and Canada. …The Ministry will continue to actively review best practices pertaining to IP management that are consistent with the Ontario Innovation Agenda.…The Ministry will continue to work with universities, research institutions, industry, and the financial sector to address issues of IP policy and management and encourage the development of IP models and approaches that will maximize the benefits of research programs to Ontario. The Ministry acknowledges the various approaches used by Ontario's research institutions to manage IP and recognizes noteworthy examples where best practices for IP management have been implemented in institutions across Ontario." (Government of Ontario, 2009c: 243).

4.5.2 Intellectual Property and U-B collaboration in the Pharmaceuticals Sector

Federal government rule-making in the area of intellectual property, and quite apart from conditions attached to federal research grants described above, can have important ramifications for the foreign investment climate and quite directly on incentives for businesses to engage in collaborative research activities with universities. As described in this section, the best example consists of federal IP policies in the pharmaceuticals sector in the late 1980s and early 1990s.

In 1987 the Canadian patent regime was substantially altered and offered brand-name pharmaceutical manufacturers greater patent protection.[91] During the legislative process

[91] The 1987 legislation: provided brand-name drug manufacturers ten years of protection against compulsory licences to import; provided brand-name drug manufacturers with seven years of protection against compulsory licences to manufacture; and, created the Patented Medicine Prices Review Board (PMPRB), an independent mandated to ensure that the prices charged by patentees for patented medicines were not excessive and to report annually on pricing trends in the

leading up to the passage of the changes to the Canadian patent regime, the Pharmaceutical Manufacturers Association of Canada (representing the "brand name" drug manufacturers and now known as Rx&D) made a public commitment that its members would boost levels of R&D in Canada to 8 percent of sales by the end of 1991 and 10 percent of sales by the end of 1996 (GOC, 1988). This commitment was subject to monitoring by a new quasi-judicial agency set up under the 1987 amendments, the Patented Medicines Price Review Board (PMPRB). The brand name manufacturers, who today account for 89.1 percent of all reported pharmaceutical R&D expenditures in Canada, largely lived up to this R&D commitment.[92]

The 1987 amendments (together with the elimination of compulsory licencing in 1992 in order to bring Canada into conformity with GATT and NAFTA IP provisions) not only spurred MNE pharmaceutical investment in Québec but led directly to the considerable expansion of research relationships between Québec's pharmaceutical manufacturers and its university sector during the 1990s and thereafter. During the period there was also a coordinated deployment of other policy instruments by the federal and Québec governments (e.g. Québec government R&D tax credits). However, as noted by Griller and Denis (2008), the IP decisions taken between 1986 and 1992 constituted the policy foundation:

> "Pharmaceutical investment in Canada grew rapidly starting in the late 1980s and early 1990s triggered by national policies to enhance intellectual property rights. Québec was a strong advocate of these policies. It added to them measures aimed at building the provincial pharmaceutical industry. Québec was successful. It retained a disproportionately high share of pharmaceutical investments during the period of rapid investment growth and captured important economic benefits as a result. …Major multinational companies respond to public policy initiatives when they make investment decisions." (Griller and Denis, 2008: 49}

4.5.3 The *Investment Canada Act* and U-B Collaboration

The *Investment Canada Act* of 1984 provides that certain investments in Canada by foreign investors may not be implemented unless the investment has been reviewed and approved by the Minister of Industry according to the "net-benefit" test.[93] During the

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pharmaceutical industry, including on ratios between research and development expenditures and sales (both for individual patentees and for the entire patented pharmaceutical sector).

[92] The Canadian PMPRB reports that the brand-name drug manufacturers achieved the 10 percent target in 1993, maintaining it until 2003, when the ratio declined to 9.1% for members of Rx&D and 8.9% for all patentees. However, the PMPRB has also reported that the R&D-to-sales ratio declined slightly for all patentees from 8.1 percent in 2008 to 7.5 percent in 2009, while the R&D-to-sales ratio for members of Rx&D declined from 8.9 percent in 2008 to 8.2 percent in 2009. The ratios have been less than 10 percent for all patentees since 2001 and for members of Rx&D since 2003. (GOC, 2010o: 1).

[93] In determining whether an investment is of "net benefit", the *Investment Canada Act* and

review process, the non-Canadian investor may give written undertakings in support of its application.

The federal Minister of Industry announced in November of 2010 that he was <u>not</u> satisfied that the proposed acquisition of the Potash Corporation of Canada by the Australian mining company BHP Billiton is likely to be of net benefit to Canada. The Minister's reported comments (Simon 2010: 1) suggest that the factors that make up the current net-benefit test are unlikely to undergo any radical revision. The factors have perhaps been intentionally drafted to provide the federal government with the maximum political flexibility in any given case (Sulzenko, 2010). However, it may well be that greater transparency in the operation and implementation of the Act will be forthcoming. Should future undertakings made by foreign investors under the *Investment Canada Act* be made public, then foreign investors may have a greater incentive to make and highlight their undertakings to work with local universities and other institutes of higher education than under the present (and confidential) regime. This may happen even though, if the past is any guide, such undertakings are unlikely to be the determining factors on deciding on the investment's net benefit to Canada.

Two Investment Canada Cases Involving U-B Collaboration Commitments

BHP-Billiton: On November 15, 2010, BHP Billiton withdrew its offer to acquire the Potash Corporation of Saskatchewan and, at that time, revealed the undertakings it had been prepared to make. The company said:

> "As a package, the proposed undertakings offered by BHP Billiton in a signed, written submission to the Minister of Industry were unparalleled in substance, scope and duration, reflecting the importance of potash to Canada and Saskatchewan. The company had offered to commit to legally-binding undertakings that would have, among other things, increased employment, guaranteed investment and established the company's global potash headquarters in Saskatoon, Saskatchewan. …BHP Billiton also offered to invest in the University of Saskatchewan to create a Mining Centre of Excellence to enhance the province's mining capabilities and to raise the international profile of both the University and the province" (BHP Billiton, 2010).

US Steel – Stelco: During 2009, and as part of litigation between the Government of Canada and US Steel Corporation in connection with US Steel's acquisition of Stelco Inc., it was revealed that US Steel had submitted thirty-one undertakings to the Minister of Industry under the *Investment Canada Act*. The major undertakings related to production, employment, planned R&D expenditures, and the location of head office, but undertakings No. 8 and No. 9 were:

> "8. The Investor will endow a Priority Chair in the Department of Materials Science and Engineering at McMaster University with a value of $2 million, to facilitate the continuing development of steelmaking technology in Ontario.
>
> 9. The Investor will continue the funding of the NSERC Industrial Research Chair in Steel Product Application at McMaster University until the expiry of the exiting term and for an additional five year term beginning July 1, 2008." (2010 Federal Court of Canada (FC) File 642)

4.6 Summary Findings

Prior to the 1980s Canadian governments did not view encouraging U-B collaboration as a significant public policy concern or a priority. Reasons for this lack of attention may be traced to:

- the business sector performed very little of its own R&D (due to a range of factors) and placed considerable reliance on imported technology;

- lack of business sector exposure to international competition and a focus on serving a small domestic market (except in commodity sectors, including forestry, agriculture, and mining, but here a range of government research institutions have traditionally played a central role);

- the growth of the public sector R&D establishment, including in areas of industrial application; and,

- the constitutional and related political context of the times which constrained a federal government role in the higher education sector even in relation to funding of university research.

Beginning in the 1980s, U-B collaboration became an increasing concern for public policy decision-makers and encouraging U-B collaboration moved on to the policy agendas of governments. This development may be traced to:

- opening up of the economy to international (especially US) competition;

- acceptance of a federal role in the funding of research at universities;

- general recognition that knowledge and its application was a source of competitive advantage (i.e., the rise of the "knowledge-based economy"); and,

- the increasing influence of "innovation systems" as the organizing framework for thinking about the role of government in strengthening the economy through micro-economic policy measures.

Canadian governments have demonstrated considerable strengths as advocates, enablers, funders and rule-makers of U-B collaboration but are also facing a number of challenges (see Table 15 beginning on the next page for summary examples). Given Canada's past and present policies for encouraging U-B collaboration, what lessons might Canadian governments draw from the policy experience of other countries?

Table 15

Summary of Policy Strengths and Challenges for Canadian Governments as Advocates, Enablers, Funders and Rule-makers for UB Collaboration

Canadian Governments as Advocates	
Examples of Public Policy Strengths	***Examples of Public Policy Challenges***
• U-B collaboration made a policy priority in the federal government's S&T strategy (although under the broader theme of "building partnerships") and in most provincial government innovation strategies. The Government of Québec is the first Canadian government to set a concrete target for U-B collaboration (the province's 2010 innovation strategy calls for: "A 10% increase in the number of collaboration between universities and businesses in relation to the annual average of 6, 000 collaborative projects observed over the past three years"). • The federal government's Science, Technology and Innovation Council is starting to measure and report every two years on U-B collaboration. • A number of provincial governments have made "machinery of government" changes that, from an advocacy perspective, symbolize the priority they attach to encouraging U-B collaboration as an integral component of their innovation strategies. • Local governments who invest in (or otherwise support) university research parks and associated "business incubator" facilities have become strong advocates of U-B collaboration as a city branding strategy. • Various public recognition award programs have been established by both federal and provincial governments.	• How can Canadian governments be more effective advocates of U-B research collaboration? What objectives and expectations should they set out for the different contributions to U-B research collaboration that can be made by universities, businesses, intermediary organizations and different levels of government? • How can provincial governments, from a U-B perspective, ensure their innovation strategies and higher education strategies are mutually supportive? • For some local governments, building and expanding on their considerable advocacy experience developed through their support for university research parks, business incubators, and local "creative economies". For all local governments, avoiding the temptation of advocating U-B solely in the context of advancing a broader (although not unimportant) policy agenda relating to municipal financing issues. • Increasing the profile of existing U-B collaboration public recognition awards and considering what new forms of recognition would be helpful. • Systematically measuring and reporting on U-B collaboration and outcomes at federal, provincial and local levels, in a timely manner and with reference to international benchmarks.

Canadian Governments as Enablers	
Examples of Public Policy Strengths	***Examples of Public Policy Challenges***
• Governments have provided financial and other forms of support for the establishment and operation of sectoral and horizontal intermediary organizations that focus on U-B collaboration and that are now characterized by: - strong national and regional coverage (for horizontal organizations); - considerable sectoral coverage (both technologies and economic sectors) although further research is required to see what important gaps may remain; - balanced and strong representation from both university and business sectors; and - are increasingly connected with one another rather than operating in silos. • Initial steps taken to co-locate government research facilities with those of universities and industry (many of the National Research of Council's research institutes for the conduct of federal research with industrial application have always been located near or adjacent to university campuses and facilities). • Many types of enabling measures to encourage U-B collaboration (and not only in research areas) have been put in place (e.g., various internships and co-operative education programs).	• How can the performance and effectiveness of sectoral and horizontal intermediary organizations be improved from a system-wide perspective: - are there areas of duplication? - are there significant gaps (by sectoral or technological coverage or with respect to intermediation activities and services offered)? - where are more government resources required and where should government support be reduced? Should government provide greater stability in the funding they provide to some of the intermediary organizations? - how can Canadian intermediary organizations be encouraged to intensify their effort to look beyond local, regional and national boundaries in the exercise of their functions? • Are there opportunities to draw greater value from existing sector skills councils through strengthening their linkages with universities?

Canadian Governments as Funders	
Examples of Public Policy Strengths	***Examples of Public Policy Challenges***
• There is no shortage of federal and provincial R&D funding programs which explicitly or implicitly are geared to encourage U-B collaboration. At the federal level, at least C$ 370 million annually is being spent to encourage U-B collaboration, and this estimate does not include more general support for R&D that may be conditioned on university and industry participation. • Provincial governments are experimenting with new funding mechanisms for supporting U-B collaboration including, for example, the introduction of various forms of "voucher" programs. • Effort has been made to incorporate private sector perspectives in decision making processes for grant awards (e.g., the Private Sector Advisory Board with respect to three specific federal granting programs) while respecting peer-review processes.	• Are Canadian governments providing sufficient funding for U-B research collaboration and through the right policy instruments? What should be the balance between support for U-B research collaboration delivered through the tax system and that delivered through direct program spending? • Canada has four major federal research agencies, four regional development agencies, and a diverse range of government line departments, all of which have programs for funding U-B research collaboration. Are there more effective and efficient institutional arrangements at the federal level for delivering public support for U-B research collaboration and related commercialization activities? • Federal government funding for research is generally acknowledged to have increased the "supply" of research through universities but there is continuing concern that is has done little to encourage the demand side (business pull). How can this balance be redressed and how will it impact on the form and extent of U-B research collaboration? • How should the challenges associated with evaluating the impact of public funding on U-B research collaboration be addressed (the same problem exists for evaluation of all public funding for R&D)?

Canadian Governments as Rule-makers	
Examples of Public Policy Strengths	***Examples of Public Policy Challenges***
• During the1980s, and in the single case of the pharmaceuticals sector, the Canadian federal government recognized and moved effectively to use federal Intellectual Property (IP) rules in a manner that encouraged U-B research collaboration to a remarkably successful extent. • There is growing recognition at both the federal and provincial government levels that university IP policies and processes are a critical vector of U-B collaboration. • There are other areas of rule-making that influence the environment for U-B collaboration and in which Canadian governments generally have a good track record. For example: - The government (Industry Canada) has commissioned studies on how the system can be strengthened (e.g. Council of Canadian Academies, 2010). - How human therapeutic products are regulated is a critical contextual element of the environment for U-B collaboration in the bio-medical sector. Over the past five years the federal government has re-invested in its regulatory system for human therapeutic products and increased the attractiveness of Canada for investments in bio-medical R&D, including through U-B research collaboration. - In December of 2010, the Presidents of the three federal research granting councils released the Second Edition of their *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans* (the First Edition was published in 1998).	• How should Canada turn its IP policies and management processes, particularly as they are found in university settings, into a competitive advantage and that maximizes their potential to drive the creation and diffusion of new knowledge – including through U-B research collaboration? • Should the federal granting councils continue to encourage greater "diversity" and "flexibility" in university IP policies and processes? The existing diversity and "flexibility" of university IP policies and processes is seen by some observers as an impediment to U-B collaboration. • From a U-B collaboration perspective, are IP issues ones of "policy" (e.g. choosing between university or inventor IP ownership models) or "process" (e.g., of bringing greater certainty and clarity – for both universities and businesses – in the negotiation and management of IP agreements)? • How can Canada's foreign investment review process be improved to help ensure the benefits of foreign investor-university research receive a higher profile and visibility than is currently the case? • How should Canada maintain and strengthen its world-class regulatory system for research, both as a matter of social necessity and of business competitiveness?

5.0 The United States

5.1 Context

There are 6,550 degree-granting institutions in the US tertiary education sector, of which some 2,000 are public institutions and 4,550 are private institutions.[94] Total enrollment (full and part-time) in public and private degree granting institutions climbed from 11.3 million in 1999 to almost 14 million in 2008 with public degree-granting institutions accounting for almost three times the number of students than private institutions (National Centre for Education Statistics, 2009). Public and private degree-granting institutions have different funding profiles, with public institutions placing greater reliance on government funding than private institutions and with private institutions placing greater reliance on tuition fees and investment income (e.g. endowments).

The US has a far greater number of associations representing universities than do Canada, the UK and Australia. Examples of US university associations include: the Association of American Colleges and Universities (AAC&U) represents 1,200 accredited public and private colleges and universities; the Association of American Universities (AAU) represents 61 US public and private research-intensive universities (the AAU also includes two Canadian universities as members: McGill University and the University of Toronto); the Association of American State Colleges and Universities (AASCU) represents 430 public colleges and universities; and the Association of Public and Land-grant Universities (APLU – formerly the National Association of State Universities and Land-Grant Colleges) represents 218 institutions.

The major university-business organization in the US is the Business Higher Education Forum (BHEF). Established in 1978, the US BHEF describes itself as:

> "The nation's oldest organization of senior business and higher education executives dedicated to advancing innovative solutions to U.S. education and workforce challenges. Composed of Fortune 500 CEOs, prominent college and university presidents, and other leaders, BHEF addresses issues fundamental to our global competitiveness. It does so through two initiatives:
>
> - The College Readiness, Access, and Success Initiative (CRI), addressing college- and work-readiness, access, and success
>
> - The Securing America's Leadership in Science, Technology, Engineering,

[94] The two major US university associations are: The American Association of College and Universities (AAC&U), which represents 1,200 member institutions—including accredited public and private colleges and universities; and the Association of American Universities (AAU), consisting of 61 U.S. and two Canadian (McGill University and the University of Toronto) public and private research-intensive universities.

and Mathematics (STEM) Initiative, promoting America's leadership in STEM (Business Higher Education Forum, Web).[95]

The US constitution does not mention education as a federal or state government responsibility. The delivery of education has largely been left to state and local governments. However, education is a major area of policy attention and action for US President Barack Obama’s Administration in the areas of: early childhood education; incenting state governments to enact K-12 teaching and curriculum reforms (e.g., through a US$ 5 billion “Race to the Top” initiative); and strengthening science, technology, engineering and mathematics (STEM) education at the K-12 and community college levels. The US federal government’s main areas of involvement in higher education are in the funding of research and the provision of student loans (Eckel and King, 2004).[96] It is the first of these areas (research) which has provided the most room for the US federal government to encourage U-B collaboration.[97]

Historically, US federal government measures for encouraging U-B collaboration have been forged in light of the national security, economic and social challenges of the day. In summary:

- By the end of the Second World War, President’s Roosevelt’s Director of Scientific Research, Vannevar Bush, had articulated the case for a continuing federal government role in both science and science education. Bush’s 1944 report to the US President, *Science the Endless Frontier*, proposed a new and federally funded national research foundation and that: “The Government should accept new responsibilities for promoting the flow of new scientific

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[95] The US Council on Competitiveness serves as another forum for bringing together leaders of US business and universities but also labour. The Council was founded in 1986 when industrial, university and labour leaders joined together to found the Council to address the national competitiveness challenges of the day. According to the Council today: “The 21st century poses new challenges to American competitiveness - globalization, high-speed communications, enterprise resilience and energy sustainability issues are forcing organizations at all levels to rethink and redefine how U.S. companies will remain competitive. After two decades, the Council on Competitiveness continues to set an action agenda to drive U.S. productivity and leadership in world markets and to raise the standard of living for all Americans.” (US Council on Competitiveness, Web).

[96] One historical exception is the Morrill Land Grant Acts of 1862 and 1890, under which the US federal government provided land grants to eligible states which could be used or sold to support the establishment and funding of higher education institutions. As recorded by Jones and Garforth (1997) the Morrill Act of 1862, signed by President Lincoln during the Civil War, was seminal in the creation of state colleges "of agriculture and the mechanic arts" in the northern United States and, by 1890, the second Morrill Act granted federal funds for the establishment of agricultural colleges in the remainder of the United States.

[97] Many of the Obama Administration’s proposed reforms for federal student loan programs were included in health care reform legislation passed by the US Congress and signed into law by the US President in 2010.

knowledge and the development of scientific talent in our youth. These responsibilities are the proper concern of the Government, for they vitally affect our health, our jobs, and our national security."(USG, 1944: 8).

- With the onset of the Cold War the US federal government increased the build-up of a large "public mission" research capacity, particularly in fields deemed vital to national security. In the 1950s and 1960s, the Federally Funded Research and Development Centres (FFRDCs) emerged. The FFRDC's, operated, managed, or administered by universities or private sector firms, encompassed activities of many of the federally funded US national laboratories.[98] An important policy assumption of the period was that a linear model of innovation applied where basic research conducted in the universities would flow through to application in the marketplace and without any push from government. At the time there was still substantial industrial research capacity (e.g. IBM Research, the Bell Laboratories, GE Research, Xerox PARC, and the Dupont laboratories) and little reason to question this assumption.[99]

- During the 1960s and 1970s, the large increase in US federal expenditures to support public mission research activities was accompanied by the development of new policy rationales for those expenditures, including "dual-use" and "commercial spin-off" arguments. The term "technology transfer" entered the public policy lexicon along with a first generation of US federal policy measures to encourage technology transfer from academic settings to industry. In 1973 and beginning as pilot projects, the National Science Foundation (NSF) created new programs to encourage technology transfer including the Industry-University Cooperative Research Centers program.

[98] In 2008, the US federal government spent US$ 14.7 billion – 14.2 percent of its total research and development (R&D) expenditures of US$ 103.7 billion in 2008 – to support 38 federally funded research and development centres managed under university or industry contractors and through sponsoring agreements with federal agencies. (USG, 2010e: 2)

[99] *The Economist* has linked the rise and decline of the largest US corporate laboratories to market structure, stating that: "The approach to R&D is changing because long-term research was a luxury only a monopoly could afford. In their heyday, the big firms dominated their markets. AT&T ran the telephone network, IBM dominated the mainframe-computer business and Xerox was a synonym for photocopying. The companies themselves saw the cost of basic scientific research as a small price to pay for such power. Modern technology firms are much less vertically integrated. They use networks of outsourced suppliers and assemblers, which has led to the splintering of research divisions. Even though big American firms still spend billions of dollars on R&D, none has any intention of filling the shoes left empty by Bell Labs or Xerox PARC. The research and development that [Vannevar] Bush tore asunder are once again becoming entwined. Old-fashioned R&D is losing its ampersand." ("Out of the Dusty Labs," March 1, 2007, online edition).

- Stagflation and perceived economic malaise in the late 1970s and early 1980s led the US federal government to re-examine the foundations of US economic competitiveness and through the lens of technological innovation performance. Japan was identified by some commentators as the benchmark competitor and also a model to be emulated. Together with a decline in industrial research capacity, these circumstances helped set the stage for the introduction of a range of US federal measures to stimulate collaborative research effort and technology transfer between the US government, university and business sectors. These were accompanied by an extensive legislative framework, including: the *University and Small Business Patent Procedures Act* (the 1980 *Bayh-Dole Act*); the *National Cooperative Research Act* (1984); and the *Omnibus Trade and Competitiveness Act* (1988).

- Following the collapse of the Soviet Union in 1991 and through much of the 1990s, US federal science and technology policies were influenced by a desire to extract a "peace dividend" as defence expenditures declined from their peak in the late 1980s. In 1993 the Clinton Administration created a five year US$ 21.6 billion Defense Reinvestment and Conversion Initiative which included expanded funding for the US Manufacturing Extension Partnerships (MEP) program. However, apart from the MEP, the 1990s were generally not marked by extensive new US federal activity aimed at encouraging U-B collaboration.[100] The major U-B policy measures during the decade were found at state and local government levels where cluster policies, particularly as promoted by Harvard University's Michael Porter, found a receptive audience.

The US federal government has deepened its engagement in encouraging U-B collaboration over the past decade and primarily through funding of R&D. Again, US federal government interventions are being shaped by the broader set of US national security, economic and social challenges. As summarized in the US National Academies of Sciences' 2005 report, *Rising Above the Gathering Storm*:

> "The dominant position of the United States depended substantially on our own strong commitment to science and technology and on the comparative weakness of much of the rest of the world. But the age of relatively unchallenged US leadership is ending. The importance of sustaining our investments is underscored by the challenges of the 21st century: the rise of emerging markets, innovation-based economic development, the global innovation enterprise, the new global labor market, and an aging population with expanding entitlements."
> (US National Academies of Sciences, 2005: C9-2).

[100] In 1993 the Clinton Administration issued the policy paper, *Vision of Change for America and Technology for America's Economic Growth, A New Direction to Build Economic Strength*. This paper linked national technology policy to US global industrial competitiveness, committed the US Administration to expanding the Manufacturing Extension Partnerships program, but generally did not focus on U-B collaboration as a policy priority. (USG, 1993).

In 2010 the US National Academies of Sciences revisited and updated their 2005 findings. The new report reaffirmed the 2005 findings but also emphasized the very different economic circumstances the US now finds itself in. On the subject of U-B collaboration the report said:

> "Companies tend to locate R&D centers near research universities because of the talent and knowledge pools that are locally available. Reductions in America's federal funding for research, coupled with declining state support and shrinking endowments along with the increased stature of foreign universities, can be expected to make U.S. universities less attractive as partners to both established and start-up firms." (US National Academies of Sciences, 2010a: 39).

5.2 US Governments as advocates

5.2.1 Advocacy Statements and Strategies

The US Administration and the US Congress have introduced various measures to encourage U-B collaboration over the past sixty years. Nonetheless, US administrations have been reticent advocates of U-B collaboration. The advocacy function was largely left to: the National Science Foundation (NSF); the US Economic Development Administration (EDA) through its advocacy of "cluster policies"; and to the US Technology Administration and its predecessors (the Office of Productivity, Technology and Innovation and the Office of Industrial Technology) within the US Department of Commerce. In 2007 the US Technology Administration was eliminated, leaving the NSF and the EDA largely alone in the advocacy field. Four examples from the past decade of an apparent reluctance by US Administrations to be leading advocates of U-B collaboration are:

- The US Secretary of Education's 2006 *Commission on the Future of US Higher Education* made a number of recommendations in its final report regarding federal, state, and local government roles in higher education. It made only passing reference to U-B collaboration in the higher education sector and mentioned no role for the federal government in encouraging U-B collaboration. (USG, 2006)

- President George W. Bush's *American Competitiveness Initiative* announced new federal R&D investments, particularly in the physical sciences and engineering, but makes no reference to U-B collaboration. (USG, 2006a)

- President Barack Obama's *Strategy for American Innovation: Driving Towards Sustainable Growth and Quality Jobs* makes only one narrow reference to the subject of U-B collaboration within the context of future skill requirements for a clean energy economy. (USG, 2009a)

- President Obama's *A Framework for Revitalizing American Manufacturing* makes only indirect reference to U-B collaboration. The framework states that

> the Administration will explore structural and regulatory reforms that have the potential to support innovation and increase production, including "Public-private partnerships that can generate mutually beneficial arrangements between major businesses and localities." (USG, 2009: 17)

Reasons for US federal government reticence in carrying out high profile U-B advocacy functions include: the delivery of higher education has largely been left to state and local governments and privately endowed institutions; local economic development activities have long been regarded as primarily the responsibility of state and local governments;[101] and that, at the federal government level, the NSF has been constrained by the tension between two of its legislated functions. The NSF's original legislative mandate included: "to initiate and support basic scientific research and research fundamental to the engineering process." The US Congress added an additional responsibility to the NSF's mandate in 1968: "to initiate and support applied research activities in academic and other nonprofit institutions."[102]

Since the Obama Administration issued its *Strategy for American Innovation* in the fall of 2009, there have been indications that the US Administration is willing to take up a more prominent advocacy role. Even so, this role remains largely focused on deriving greater economic and social value from federal research funding. Examples include:

- **Grand Challenges Solicitation (February 2010).** President Obama's September 2009 *Strategy for American Innovation* set out "grand challenges" of the 21st century which science and technology could address in areas such as health, clean energy, national security, and education and life-long learning. The US Administration's Office of Science and Technology Policy (OSTP) subsequently issued a Federal Register notice requesting public comments on:

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[101] Eberts and Erickcek (2002) have said: "Economic development activities are primarily the responsibility of state and local governments, with only limited assistance from the federal government. The federal government has chosen not to promote the economic development of one region over another, except in the case of severe poverty in specific areas, particularly inner cities." Eberts and Erickcek (2002: 6). However, the spatial distribution of US federal government spending for R&D can have important local economic development impacts. Fossum, Painter, Eisemean and Ettedgui (2004) report that, over the period 1996-2002, over 55 percent of all federal R&D funds awarded to the nation's universities and colleges went to institutions in only nine states: California, Illinois, Maryland, Massachusetts, Michigan, New York, North Carolina, Pennsylvania, and Texas.

[102] The tension between these two NSF responsibilities was apparent even at the time of the 1968 extension of NSF responsibilities to initiate and support applied research activities. The Director of the NSF in 1968, Leland Haworth, wrote that: "This new authority undoubtedly will affect a number of programs of the Foundation. It will also make it possible for the Foundation to support efforts at academic institutions aimed at providing the knowledge base required to deal with the contemporary problems of our modern science-oriented society. However, it is not the intent of the Foundation to support applied research at the expense of the important fundamental science activities which it now supports."(USG, 1968: xii).

- what are the appropriate roles of the government, industry, academia and other stakeholders in achieving the grand challenges?

- what new forms of collaboration should be explored?

- what are the appropriate roles for pre-competitive collaboration and market-based competition?

- what models are appropriate for creating an architecture of participation that allows many individuals and organizations to contribute to these grand challenges? (USG, 2010h: 5634-5635).

- **Public consultations on the commercialization of federally funded university research (March 2010).** This public consultation was initiated by the US Administration's Office and Technology and Science Policy and the National Economic Council.[103] The Request for Information (RFI) notice (which does not include the NSF as one of the requesting authorities) states that:

  > "This RFI is designed to collect input from the public on ideas for promoting the commercialization of federally funded research. The first section of the RFI seeks public comments on how best to encourage commercialization of university research. The second section of the RFI seeks public comments on whether POCCs [Proof of Concept Centres] can be a means of stimulating the commercialization of early-stage technologies by bridging the "valley of death." (USG, 2010b: 14476–14478).

  One submission in response to this request for information came from representatives of over 40 major US public and private sector organizations involved in university technology transfer and states that:

  > "The most important change in public policy and research funding would be for the federal government to provide funding to support commercialization activities that is customized to local circumstances, addressing the specific capabilities, conditions, and needs of an area. Historically, the federal government has focused its funding on research and largely has ceded any efforts to bring the results to the market to programs funded by universities, states, local government, and foundations. With record state deficits and reduced spending by foundations, the resources to commercialize research are under great strain, and it is unlikely that there will be a broad expansion of activities in this area unless the federal government dedicates significant resources to the activities. …It is important that any new federal activity in this area build off the existing efforts that are underway which are supported

[103] The strong interest expressed in this consultation resulted in an extension of the deadline for comments by an additional month.

> at the state, university and local level and that resources be made available to whomever the most appropriate actor may be. In some cases, that actor might be at the university; in other cases, it might be an independent, non-profit organization." (State Science & Technology Institute, 2010b: 7)

- **The creation of an Office of Innovation and Entrepreneurship (OIE) and a National Advisory Council on Innovation and Entrepreneurship (NACIE) within the US Department of Commerce.** The US Secretary of Commerce, Gary Locke, announced the formation of the OIE and the NACIE in September of 2009 (USG, 2009j). Section 601 of the America COMPETES Reauthorization Act of 2010 states that the OIE will be responsible for such functions as developing and advocating policies to accelerate innovation and advance the commercialization of research and development, including federally funded research and development.

  One of the OIE's first activities was to host a national forum in February 2010 on the roles of universities in innovation, economic development, job creation, and commercialization of federally funded research. (Interestingly, however, this specific event - attended by university leaders and business sector representatives - was closed to the public and the media). During the following five months, the US Commerce Secretary hosted four public regional innovation forums at the University of Massachusetts, the University of Southern California, the University of Michigan and Georgia Institute of Technology. In each forum the Secretary addressed the role of universities in innovation, economic development, job creation and commercialization of federally funded research (USG, 2010z).

- **President Obama's "Sputnik Moment."** A major theme the President's January 24, 2011, State of the Union address was "winning the future through American Innovation." The President presented the innovation challenge as this generation's "Sputnik Moment" The President did not make any direct reference in his address to encouraging U-B research collaboration, but did set out his view that the US federal government has a role to play in driving innovation: "Our free enterprise system is what drives innovation. But because it's not always profitable for companies to invest in basic research, throughout our history, our government has provided cutting-edge scientists and inventors with the support that they need." (USG, 2011). Speaking at Penn State University one week later, the President stated: "Now, this campus will be the product of a true collaboration. What… you have done is develop an innovative model for how to do research. Government pulled resources from across different agencies to support your effort, from programs that train new workers and skills to loans for small businesses that will grow from your breakthroughs." (USG, 2011a).[104]

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[104] Penn State University received $US 472 million of its US$ 780 million total research expenditures in 2009-10 from US federal government sources, while industry-sponsored research accounted for just over US$ 100 million of the University's research spending (Penn State University, 2011: 4). Based on 2008 data, Penn State is the 3rd ranked university in the US for

5.2.2 Measuring and Reporting on U-B collaboration

The main curator of the US evidence base for U-B collaboration, and US innovation performance more broadly, is the US National Science Board (NSB). A main instrument for disseminating information has been the NSB's annual publication *Science and Engineering Indicators*. Over recent years, the US administration, the NSF, and the National Academies of Sciences, have recognized that a much better job must be done in measuring and communicating the benefits of government investments in science, and including investments in collaborative research. For example:

- The US has introduced a new *Business R&D and Innovation Survey*. The survey was developed jointly by the National Science Foundation (NSF) and the U.S. Census Bureau and is based on recommendations from the US National Research Council's Committee on National Statistics. The first survey (which is mandatory for recipients to complete) was mailed to a representative sample of about 40,000 companies in January 2009. Preliminary results from the survey were published in 2010 and final results are expected to be available in early 2011. The survey's section on "Management and Strategy of R&D" (the results from which will not be available until 2011) includes the following questions:

  > "Did your company perform any of the following activities with universities, students, or academic faculty in 2009?
  >
  > - Hired academic consultants for short-term projects in science and engineering?
  > - Hosted student interns pursuing undergraduate or graduate degrees in science or engineering for at least one month?
  > - Hosted post-doctoral fellows in science or engineering for at least one month?
  > - Had scientists or engineers from your company who served as visiting scientists or engineers at a college or university for at least one month?
  > - Made monetary gifts to universities or colleges that were restricted to supporting R&D?" (USG, 2009b: 35)

- The NSF introduced a revised Higher Education Research and Development Survey in 2010 that will permit the capture and reporting of more detailed information on sources and uses of funds by the US higher education sector. (USG, 2010x). Already the US National Academies of Sciences is recommending further improvements to this survey:

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industry funded research. Duke University ranked number 1 in 2008 at US$ 152 million in industry funded research. Ohio State University ranked number 2 at US$ 128 million (USG, 2010s: Appendix Table 5-10).

> "Principal university and professional organizations and federal science agencies should coordinate efforts to develop a more balanced set of measures of total university knowledge exchange with the private sector to improve understanding of the process and its performance. This should result in a manageable set of questions incorporated in the National Science Foundation's annual survey of higher education institutions' expenditures on research and development and in other private surveys. To the extent possible, the responses should be capable of being linked to other data sets on research outputs, new business creation, and industrial performance." (US National Academies of Sciences, 2010: 12).

- STAR METRICS is a federal and university partnership launched in 2010 with US$ 1 million in federal funding. The objective of the partnership (that includes 60 US universities) is to develop an empirical framework to measure the outcomes of science investments and demonstrate the benefits of scientific investments to the public. US federal government participation in the project is led by the National Institutes of Health, the National Science Foundation and, within the Executive Office of the US President, the Office of Science and Technology Policy.

5.3 US Governments as Enablers

5.3.1 Support for Intermediary Organizations

Examples of US federal and state government support for intermediary organizations are presented in two categories: sectoral organizations and horizontal organizations.

5.3.1.2 Sectoral Organizations

Examples of sectoral organizations with U-B research intermediation as a core activity and which receive financial support from federal, state, and in some cases, local governments, include:

The Semiconductor Research Corporation (SRC)

The SRC is one of the largest industry-led and consortium based US intermediary organizations. It finds its origins in the early 1980s when the US semiconductor industry came under increasing international competitive pressure. The industry, led by the Semiconductor Industry Association, responded in three ways:

- it sought relief from what it regarded as unfair competition in the US domestic market through trade remedies (e.g. anti-dumping and countervailing duties);
- it established, in 1982, the non-profit Semiconductor Research Corporation (SRC) to manage university research sponsored by SIA members; and

- it established, in 1987, SEMATECH, a research consortium of semiconductor manufacturers. In December of 1987, President Reagan signed into law the first year of federal funding for SEMATECH and, between 1986 and 1996, the US federal government provided SEMATECH with US$ 100 million in annual funding. Since 1996 SEMATECH has been financed primarily by its business members. The SRC manages SEMATECH's university research programs because SEMATECH itself became an SRC member.[105]

SRC's goal is to define common industry needs, invest in and manage the research that will expand the industry knowledge base, and attract students to study semiconductor technology. Since 1982 and through to the 2nd quarter of 2010, the SRC has overseen US$ 1.6 billion in sponsored research at universities. An estimated US$ 770 million or 48 percent of its total research portfolio was funded from industry sources while the remainder, US$ 844 million or 52 percent, was funded from government sources.[106] The SRC reports that it helps its industry members through a variety of means, including

- lowering the search costs to identify promising research topics and employable graduate students ;

- lowering training cost by providing a venue for relevantly educated graduate students;

- lowering the cost of contracting with SRC-affiliated universities because the legal foundation to protect members' intellectual property rights is already in place;

- increasing the absorptive capacity of members by making available eminent faculty consultants knowledgeable of the challenges articulated in the ITRS [International Technology Roadmap for Semiconductors]; and

- raising the returns on a member's research and development portfolio by providing a way to achieve a lower-cost, diversified research portfolio investment. (Semiconductor Research Corporation: 2010 Web).

One feature of the SRC is its industry consortium structure. On this point the SRC has stated:

> "Industry consortia fund only a small portion of university research. Nevertheless, as major industrial laboratories decline and industry looks for new

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[105] The establishment of SEMATEC, and also another major US industry research consortium, the Microelectronics and Computer Technology Corporation, was facilitated by changes in US anti-trust regulation with the passage of the 1984 *National Cooperative Research Act*.

[106] As reported by Mr. Larry W. Sumney, President and Chief Executive Officer, Semiconductor Research Corporation, in a telephone conversation with the author of this report.

> sources for research, industry-university collaboration has the potential to grow. Stable contributions to universities coupled with its potential leveraging of other funding sources should make collaboration with industry consortia attractive to universities. A strong capacity for commercialization of university research should make industry consortia attractive to government.” (Semiconductor Research Corporation, 2010a: 8).

In a 2010 submission to the US government, the SRC has highlighted a number of areas where it believes the US federal government can act to better support the SRC consortia model:

> “The federal government can and should facilitate, encourage, and incentivize more industry consortia by (1) joining with industry to identify common technology needs (2) increasing the R&D tax credit for such investments (i.e. industry spending on university research through nonprofit consortia), (3) matching industry funding on a basis greater than the one-to-one ratio for government industry support and (4) calling upon agencies to use existing flexible authorities (e.g., Other Transaction Authority) that are suited to such collaborations between the public and private sector.” (Semiconductor Research Corporation, 2010a: 1).

SRC’s operational expenses are covered by member fees from its 20 core industry members and affiliated and associate industry members. Government agencies are treated as “participants” by SRC with some, although not all, paying membership fees. Government participants include: the US Defence Advanced Research Project Agency; the US National Institute of Standards and Technology; the US National Science Foundation; five state government agencies; and also the UK’s Engineering & Physical Sciences Research Council. Since 1982, SRC has entered into sponsored research funding arrangements with over 249 universities and technology institutes. In 2009 alone, the SRC sponsored research conducted at 136 universities and technology institutes, including three from Canada (see Table 16 next page).

Table 16
Universities and Technology Institutes with Sponsored Research funded through the Semiconductor Research Corporation in 2009

1	Arizona State University
2	Auburn University
3	Binghamton University/SUNY
4	Boston College
5	Boston University
6	Brigham Young University
7	Brooklyn College, City University of NY
8	Brown University
9	California Institute of Technology
10	Carnegie Mellon University
11	Case Western Reserve University
12	City College of New York
13	Clarkson University
14	Colorado School of Mines
15	Colorado State University
16	Columbia University
17	Cornell University
18	Dartmouth College
19	Delft University of Technology
20	Drexel University
21	Duke University
22	Emory & Henry College
23	Georgia Institute of Technology
24	Harvard University
25	Hiroshima University
26	Howard University
27	Illinois Institute of Technology
28	Indian Institute of Science
29	Indian Institute of Technology/Mumbai
30	Indian Institute of Technology/Delhi
31	Indian Institute of Technology/Guwahati
32	Indian Institute of Technology/Kharagpur
33	Iowa State University
34	Johns Hopkins University
35	Lehigh University
36	Louisiana State University
37	Macalester College
38	Massachusetts Institute of Technology
39	**McGill University/Montreal**
40	Michigan State University
41	Nanyang Technological University/Singapore
42	National University of Singapore
43	New Jersey Institute of Technology
44	New York University
45	North Carolina A&T State University
46	North Carolina State University
47	Northeastern University
48	Northwestern University
49	Oklahoma State University
50	Oregon State University
51	Pennsylvania State University
52	Politecnico di Torino/ Torino, Italy
53	Portland State University
54	Poznan University of Technology/ Poznan, Poland
55	Princeton University
56	Purdue University
57	Rensselaer Polytechnic Institute
58	Rice University
59	Rochester Institute of Technology
60	Royal Institute of Technology (KTH) / Stockholm
61	Rutgers University
62	San Jose State University
63	Southern Illinois University
64	Southern Methodist University
65	Stanford University
66	Stony Brook University/SUNY
67	Swiss Federal Institute of Technology
68	Technion-Israel Institute of Technology
69	Tel Aviv University
70	Temple University
71	Texas A&M University
72	Texas Tech University
73	The Ohio State University
74	Tufts University
75	Univ. at Albany/SUNY
76	Univ. at Buffalo/SUNY
77	Univ. of Alabama
78	Univ. of Arizona
79	Univ. of Arkansas/Fayetteville
80	Univ. of Bayreuth
81	Univ. of Bologna
82	**Univ. of British Columbia**
83	Univ. of California/Berkeley
84	Univ. of California/Davis
85	Univ. of California/Irvine
86	Univ. of California/Los Angeles
87	Univ. of California/Riverside
88	Univ. of California/San Diego
89	Univ. of California/Santa barbara
90	Univ. of California/Santa Cruz
91	Univ. of Central Florida
92	Univ. of Colorado/Boulder
93	Univ. of Connecticut
94	Univ. of Delaware
95	Univ. of Denver
96	Univ. of Florida
97	Univ. of Glasgow
98	Univ. of Houston
99	Univ. of Illinois/Urbana-Champaign
100	Univ. of Iowa
101	Univ. of Kentucky
102	Univ. of Louisiana/Lafayette
103	Univ. of Louisville
104	Univ. of Maryland
105	Univ. of Massachusetts
106	Univ. of Michigan
107	Univ. of Minnesota
108	Univ. of Nebraska/Lincoln
109	Univ. of Nebraska/Omaha
110	Univ. of North Carolina/Chapel Hill
111	Univ. of North Carolina/Charlotte
112	Univ. of North Texas
113	Univ. of Notre Dame
114	Univ. of Oklahoma
115	Univ. of Pennsylvania
116	Univ. of Pittsburgh
117	Univ. of Rochester
118	Univ. of South Florida
119	Univ. of Southern California
120	Univ. of Tennessee/Knoxville
121	Univ. of Texas/Arlington
122	Univ. of Texas/Austin
123	Univ. of Texas/Dallas
124	Univ. of Texas/Pan American
125	**Univ. of Toronto**
126	Univ. of Trento
127	Univ. of Utah
128	Univ. of Virginia
129	Univ. of Washington
130	Univ. of Wisconsin/Madison
131	Vanderbilt University
132	Virginia Tech
133	Waseda University
134	Washington State University
135	Yale University
136	Youngstown State University

Source: Semiconductor Research Corporation Annual Report 2009. [emphasis added]

National Center for Manufacturing Sciences (NCMS)

The NCMS finds its origins in the mid-1980s when US President Ronald Reagan issued a National Security Decision Directive setting out a number of actions with respect to machine tool imports and a program to modernize US machine tool capabilities, including: "The provision of up to $5 million in Federal Government matching funds per year of the next three years for a private sector technology centre, to help the machine tool industry make advances in manufacturing and design." (USG, 1986: 4). By December of 1986, the National Centre for Manufacturing Sciences (NCMS) had been identified as the recipient for the federal funding (USG, 1986a: 1).

By 2010 the NCMS had grown to include over 200 US manufacturing firms and a number of US university members. It describes itself as the largest cross-industry collaborative research and development consortium in North America, and is the only consortium effort in the U.S. devoted exclusively to manufacturing technologies, processes and practices. The NCMS does not perform R&D itself, but does assemble funding (including from federal and state government sources) and brings together business and university R&D performing organizations to conduct the research. The NCMS also provides technology transfer consulting services for its member organizations.

The most recent NCMS initiative, a *Strategy to Revitalize American Manufacturing*, was launched in September 2010. It is supported by the US Alliance for High Performance Digital Manufacturing, an industry organization that includes GE, Caterpillar, Proctor and Gamble, Lockheed Martin; Intel and Microsoft. The goal of the initiative is to provide small and medium sized US manufacturers with access to high performance computing (HPC) facilities and services for digital manufacturing and that are often found at US universities and national laboratories. The initiative is primarily concerned with process rather than product innovation (NCMS, 2010: 3). According to the HPC research consultancy Intersect 360 Research:

> "The NCMS plan is simple and resonant, in that it responds to exactly what the SMMs [small and medium sized manufacturers] have said they need. U.S. manufacturers specifically want this from an organization like NCMS rather than an academic institution or government agency. There is a sense of trust associated with a nonprofit whose stated mission is the enhancement of manufacturing in the United States." (NCMS, 2010: 5).

The NCMS is now in the process of raising US$ 12 million in start up funding for up to 12 "Predictive Innovation Centres" over the next three years, including from: General Electric, Caterpillar, Proctor and Gamble and Lockheed Martin; hardware and software vendors such as Intel, Microsoft, Cray, SGI and Altair; and also from federal and state governments.

The Research Partnership to Secure Energy for America (RPSEA)

The RPSEA is a non-profit corporation formed in 2005 by a consortium of US research universities, industry and independent research organizations. It characterizes its mission as: "to provide a stewardship role in ensuring the focused research, development and deployment of safe, environmentally sensitive technology that can effectively deliver hydrocarbons from domestic resources to the citizens of the United States." (RPSEA, 2010 Web). One of the organization's main functions is to manage a portion of research funds flowing from the Royalty Trust Fund created by the US Congress in the *Energy Policy Act* of 2005. As described by the RPSEA's Michael Ming:

> "The Department of Energy's (DOE) National Energy Technology Laboratory (NETL) competitively selected RPSEA in May 2006 and signed an oversight

> contract with RPSEA on January 4, 2007. RPSEA went to work with a budget of $37.5 million a year in directed spending for 10 years not subject to congressional appropriation, plus a core of 70 members and a plan to leverage its research money into the most effective research partnership ever assembled for the energy industry. Partnership and membership form the foundation of the RPSEA open innovation public/private partnership. Together, they build the research steps to maximize the value of domestic resources through more efficient and lower cost exploration, drilling and production techniques in three program components—Ultra-Deepwater (UDW), Unconventional Resources and Small Producer. NETL internally manages an additional $12.5 million research program that is complementary to and supportive of RPSEA for a combined annual program of $50 million. Also, NETL has oversight responsibility for RPSEA and the entire program." (Ming, 2009: 1)

RPSEA's board of directors in 2010 was chaired by the head of Texas A&M University's Department of Engineering and included six members drawn from US universities and 15 members with private sector affiliations.

The Hollings Manufacturing Extension Partnership (MEP) Centres[107]

The Hollings MEP was originally authorized by the US Congress in 1988 and underwent major expansion in the 1990s. Today there are 60 MEP Centers across the US. The objective of the centres is to assist small and medium-sized manufacturing companies use and apply manufacturing knowledge and technologies. The MEP centres are structured either as separate non-profit corporations or as part of other organizations such as universities (the most common partnership), state agencies, technology centers, or economic development groups (Shapira, 2001).

The centres are one vehicle for US Department of Commerce to fund other intermediary organizations focussed on the manufacturing sector. In October 2010 The National Institute of Standards and Technology (NIST) within the US Department of Commerce announced US$ 9.1 million in funding for cooperative agreements for 22 projects designed to enhance the productivity, technological performance and global competitiveness of U.S. manufacturers.

President George W. Bush's FY 2009 budget request called for an orderly end to federal funding for the Hollings Manufacturing Extension Partnership but the US Congress continued to provide funding.[108] The first two fiscal year budget requests by the Obama

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[107] In 2004 the Manufacturing Extension Partnership Program and associated centres were renamed as the Hollings Manufacturing Extension Partnership program and Hollings MEP Centres in honour of US Senator Ernest Frederick Hollings.

[108] In July 2009, the US National Governors Association issued its *National Research, Development, and Technology Policy Position* that includes the statement: "Governors strongly encourage Congress to fund the Manufacturing Extension Partnership (MEP) at a level that ensures the program will continue to operate effectively. The MEP has been instrumental in

administration asked for new resources for the MEP. Enacted funding for the program climbed from US$ 89.6 million in FY 2008 to US$ 124.7 million in FY2010. President Obama's FY 2011 budget requests a further increase to US$ 129.7 million.

The Critical Path Institute

In 2004 the US Food and Drug Administration (FDA) launched a Critical Path Initiative for transforming the way FDA regulated products - human drugs, biological products, medical devices, and veterinary drugs - are developed, evaluated, and manufactured. As part of this initiative, the FDA supported the creation of a new non-profit institute, the Critical Path Institute (C-Path). Since 2005, C-Path has received over US$ 20 million in grants and US$ 10 million in "contributions" from public and private organizations, including from the FDA, the State of Arizona, the City of Tucson, Pima County, regional municipalities, foundations, organizations, and private individuals. C-Path reports that in order to serve as a neutral and trusted third party for collaborators, it does not accept monies from organizations that develop products regulated by the FDA or that would create a real or perceived conflict of interest. However, C-Path does manage industrial consortia of companies willing to share pre-competitive knowledge and work in support of projects that are identified as high priority by the FDA and are in the interest of public health (section 5.5.4 of this report provides an extended discussion of C-Path within the context of the US regulatory system for human therapeutic drugs).

5.3.1.2 Horizontal Organizations

Examples of US horizontal organizations with U-B research intermediation as a core activity and which receive financial support from federal, state, and in some cases, local governments, include:

The Government-University-Industry Research Roundtable (GUIRR)

GUIRR was established in 1984 by the US National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. Its original activities were focussed on the reduction of administrative burdens on recipients of federal research grants and contracts. Since the 1990s, GUIRR has engaged in new areas more relevant to encouraging U-B collaboration. In 2003 GUIRR served as the neutral convener for what is now called the University-Industry Demonstration Partnership (UIDP – see discussion below). In 2008, GUIRR launched a Working Group on International Research Collaborations, including government, private sector, and university members, and with a mandate to "facilitate a more structured approach to international research collaborations and build a solid infrastructure to help companies and universities deal with a range of administrative and legal complexities."(Carfora et. al., 2009: 10).

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cultivating a partnership among the federal government, states, and manufacturers, and has helped small- and medium-sized manufacturers modernize to stay competitive in the global marketplace." (National Governors Association, 2009: S4.5.2).

Funding for GUIRR's core activities comes from the National Institutes of Health, the National Institute of Standards and Technology and the departments of Defense, Homeland Security, and Health. Some 40 other company and university organizations contribute funding for GUIRR's other special projects. (USG, 2010g).

The University-Industry Demonstration Partnership (UIDP)

The UIDP was created in 2006 through an initiative of the US National Academies of Sciences. Today it has 75 members, including 50 universities, 20 companies, and federal and state government representatives. The UIDP, institutionally located within the US National Academies of Sciences but funded largely through member fees, characterizes its three main services as: networking; learning; and building trust. The UIDP considers one of its functions as enabling successful negotiations between university, industry and government partners:

> "Understand who's at the negotiating table: Industries and institutions sit side-by-side at the Partnership to problem solve for the collective good, at the same time as find ways to advance the goals of their respective organizations. The benefits of these discussions are invaluable and form the foundation for future negotiations, built upon stronger understanding of each others' cultures and interests. Active participation in the UIDP is one of the most profitable investments that can be made to avoid wasting time, money and resources dealing with intractable university-industry partnership issues." (UIDP, 2010)

State and local government support for horizontal intermediary organizations

There are many examples of intermediary organizations at US state and local levels, including: Pennsylvania's Ben Franklin Technology Partners; Oklahoma's non-profit i2E, Inc.; Ohio's JumpStart organization; San Diego's CONNECT organization; the Georgia Research Alliance; and the Arkansas Research Alliance. With respect to the last three of these:

- **San Diego's CONNECT organization.** CONNCECT was founded in 1985 under the leadership of Richard C. Atkinson (former Director of the NSF, Chancellor of the University of California, San Diego (UCSD) between 1980 and 1995, and later President of California's university system) and Mary Walshok, Associate Vice Chancellor of UCSD. Today CONNECT reports that the key elements in CONNECT's formula for acceleration of innovation are: accelerating the success of innovators at all stages of growth; connecting innovators to the financial resources necessary for success; representing innovation companies on Capitol Hill and in Sacramento on barriers to commercializing discoveries; promoting San Diego's ground breaking discoveries and breakthrough innovators; and accelerating innovation with shared information and collaboration (CONNECT, 2010: 2).

CONNECT's initial launch and some of its later programs were supported by the city of San Diego's Regional Economic Development Corporation while some of its initial programs were funded through a defence adjustment grant from the US federal Economic Development Administration. (USG, 2000: 42). Today CONNECT is not dependent on public funding for its operations although one of its many intermediary functions is to help assemble and manage public and private funding for various projects. For instance, CONNECT's 2010 annual report states that:

> "San Diego has been designated as an Innovation Hub (iHub) by the California Governor's Office of Economic Development (GoED). The iHub certification has been granted to catalyze the growth of the region's unique technology convergence clusters in mobile health, biofuels and solar storage. CONNECT is managing the 35+ member iHub consortium that includes UC San Diego, San Diego State University, the region's five regional economic development agencies, UC San Diego's von Liebig Center for Entrepreneurism and Technology Advancement and others. The iHub network is collaborating to attract federal and state grant and contract funding to accelerate commercialization and promote start-up formation." (CONNECT, 2010: 8).

- **The Georgia Research Alliance (GRA).** Combes and Todd (1996) trace the GRA's origins to the early 1980s when State of Georgia sought to host the Microelectronics and Computer Consortium (MCC) for pre-competitive research (Georgia's bid was not successful and the MCC was eventually head-quartered in Austin, Texas). However, as a result of the effort to win the competition, Georgia Governor Joe Frank Harris established the Governor's Research Consortium in 1985 as an R&D investment program to establish major research centers of excellence at Georgia research universities. According to Combes and Todd:

> "The investments made by the Consortium, like those made by many other states in the 1980s, established first-class research facilities but put no funding into recruiting research personnel. Recognizing that research capabilities needed investments in addition to buildings, a group of prominent Atlanta businessmen conceived the Georgia Research Alliance (GRA) in 1990, an election year. The GRA concept emphasized collaboration and cooperation among the state's research universities, in the model of Research Triangle Park in North Carolina. This emphasis required that the state's flagship research universities, Georgia Tech, the University of Georgia, and Emory University embrace the GRA as an appropriate model for science-based development. Thus, the business group promoting the GRA enlisted the presidents of these three universities at an early stage, with the understanding that other research universities would join the Alliance later. In 1990, when Governor Harris could not run for a third term, both Democratic (Zell Miller) and Republican (Johnny Isakson) candidates were approached by those

> promoting the GRA, and both adopted the concept as part of their respective economic development pro-grams. Zell Miller was elected in November and restated his support for the GRA." (Combes and Todd, 1996: 70).

The GRA reports that since its establishment it has: brokered hundreds of "deals" on behalf of the state's research universities; recruited scores of world-renowned scientists, called Georgia Research Alliance Eminent Scholars®; fueled the launch of more than 150 companies; and served as a catalyst for two dozen centers of research excellence – "university-based enterprises that serve as magnets for scientists and federal research dollars." (GRA, 2010 Web). Today GRA operates as an independent not-for-profit entity governed by representatives from business and academia. The GRA receives a state appropriation for investment in university-based research opportunities, but its operating costs are funded through foundation and industry contributions.[109]

- **The Arkansas Research Alliance (ARA)**. The ARA is modeled on the GRA. In 2007 it received start-up operational funding for its first two years (US$ 500 thousand) from the State of Arkansas. According to the ARA:

> "ARA has two programs that exist to strengthen the economic competitiveness of Arkansas. The ARA Scholars program…is the cornerstone economic development initiative for the ARA. The [ARA] board awarded two inaugural ARA Scholars with three-year grants in 2010. The scholars are experts in their respective fields and will strive to convert research into economic growth in strategic focus areas for the state. They will have an immediate impact on the research infrastructure in the state. As a pilot program, the ARA Research Conferences will bring members of the public and private sectors together to build relationships that will increase federal grants and create economic development through commercialization. As the two key programs mature and gain momentum, the potential for economic progress becomes tangible." (Arkansas Research Alliance, 2010: 9).

To enable the creation of the ARA, the Arkansas State Legislature amended the governing statute of the Arkansas Science & Technology Authority (the state

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[109] However, the GRA, like some other intermediary organizations in Canada, the UK and Australia, are vulnerable to the vagaries of government budgeting. In January 2011 the SSTI reported that Georgia Governor's Nathan Deal's proposed FY12 budget provides the GRA with US $4.5 million in FY12, a 75 percent reduction from the current year: "The governor's budget also would transfer GRA funds to the Department of Economic Development, a move that would align TBED with the state's more traditional economic development efforts. GRA's research and technology commercialization programs, which often are replicated by other states and regions, would be severely impacted if the governor's budget is adopted in its current form. Funding for GRA's Eminent Scholars, which is used to match university funds for recruiting world-class researchers to the state, would be eliminated." (State Science and Technology Institute, 2011).

government authority with a mission to "advance the talent and innovation necessary for Arkansas to prosper" and that funds a variety of state S&T programs) to permit it to support the ARA. The language of the amendment suggests that job creation was foremost on the minds of Arkansas legislators in 2007:[110]

> "(a) The Arkansas Science and Technology Authority may work with the chancellors and presidents of research universities and the private business sector to support collaborations establishing an alliance for the purpose of improving the economy of the state through:
> (1) Improving research infrastructure;
>
> (2) Increasing the focus on job-creating research activities within or supported by the research universities; and
>
> (3) Expanding job-creating research activities toward producing more knowledge-based and high-technology jobs in this state.
>
> (b) The authority shall designate no more than five (5) institutions of higher education as research universities for the purposes of this subchapter." (Government of Arkansas: Arkansas Research Alliance Act: Section 15-3-304),

5.3.2 Other Enabling Measures

A number of US federal government programs are targeted at encouraging U-B collaboration in education and teaching areas, although these are relatively small in scale. Three examples are:

The National Science Foundation (NSF) Advanced Technological Education (ATE) Program

The federal *Scientific and Advanced-Technology Act of 1992* mandated the establishment of the NSF's ATE program. The ATE funds specific projects but also 36 national and regional Centers of Excellence which enter into partnerships with local and regional industries to deliver their educational programs. (USG, 2010: 2) The centres seek to encourage collaboration between educators and employers and are somewhat analogous to the sector skills councils found in Canada, the UK and Australia. The US ATE centres are focused on two-year colleges, but a number of them have developed strong linkages with state university systems. For example, the NSF Advanced Technology Education (ATE) Regional Center for Nanofabrication Manufacturing Education located at Penn

[110] Job creation remains front and centre for the ARA itself. The opening paragraph of the ARA's 2010 annual report states: "The Arkansas Research Alliance remains true to its vision of creating long-term economic opportunities through job-creating research. In its first two years, this organization has earned a reputation as a trusted partner and collaborator." (Arkansas Research Alliance, 2010: 1),

State University Park Campus (also the location for the Penn State University's Center for Nanotechnology Education and Utilization).[111] President Obama's 2011 budget includes a request for US$ 64 million for the ATE and, according the NSF, this is the beginning of a growth trajectory that is expected to reach US$ 100 million by FY 2013.

NSF Grant Opportunities for Academic Liaison with Industry (GOALI) program

GOALI was an outgrowth of a small scale initiative launched by the NSF in 1989 and which expanded during the 1990s to become a NSF-wide program (Martin-Vega et. al., 2002). The NSF Budget Request to Congress for FY 2011 for GOALI is US$ 18.6 million. The program's objective is: "…promoting university-industry partnerships by making project funds or fellowships/traineeships available to support an eclectic mix of industry-university linkages. Special interest is focused on affording the opportunity for: faculty, postdoctoral fellows, and students to conduct research and gain experience in an industrial setting; industrial scientists and engineers to bring industry's perspective and integrative skills to academe; and interdisciplinary university-industry teams to conduct research projects." (USG, 2009k: 4).

RE-ENERGYSE (Regaining our Energy Science and Engineering Edge)

The RE-ENERGYSE program was originally proposed in 2009 by the Obama Administration. The program proposal consists of a variety of elements, including: "Partnerships between industry and two-year and four-year colleges to strengthen education for technicians in the clean energy sector, focusing on curriculum development, teacher training, and career pathways from high schools to community colleges"; and "Interdisciplinary energy graduate programs at the master's and Ph.D. level that integrate science, engineering, entrepreneurship, and public policy." (USG, 2009h). It remains unclear what form these industry partnerships may take. As of January 2011, President Obama's FY 2011 budget request for RE-ENERGYSE of US$ 74 million (substantially less that his FY 2010 budget request for US$ 100 million) had not been approved by the US Congress.

5.4 US Governments as Funders

The main US federal government policy instrument for encouraging U-B collaboration since the Second World War has been, and remains today, funding for R&D. US federal budget authority for R&D spending in FY 2010 is US$ 148.5 billion, an increase of 2 percent over FY 2009. Measured by government function, defence absorbs the largest share of US federal R&D spending (58 percent in FY 2010) followed by health (21 percent in FY 2010). (USG, 2010s: C4-5).

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[111] NSF ATE large projects and centers are required to have a National Visiting Committee. The committee is made up of leaders in industry, education, workforce and economic development from across the US, with local representation. They serve as advisors working with the grantees and NSF to help achieve the stated goals and objectives. (Florida ATE Web: August 2010).

The examples of US funding measures to encourage U-B collaboration are presented below under three headings:

- NSF and National Institutes of Health research grant conditions and funding programs;
- other research funding programs and institutions at the federal government (including energy and defence) and state government levels.
- other fiscal incentives for U-B collaboration (i.e., federal and state-level tax credits).

5.4.1 National Science Foundation (NSF) and National Institutes of Health (NIH) Research Grant Conditions and Funding Programs

NSF Research Grant Conditions and Funding Programs

The NSF supports research and education across all fields of science and engineering. In FY 2010, the NSF budget was US$ 6.9 billion. The NSF reports that, for FY 2009, 74 percent of its budget went to over 2,000 colleges, universities, and academic consortia and primarily through competitively awarded grants (NSF, 2010: Web).

NSF grant conditions and funding programs are often designed to encourage U-B collaborative research. However, some observers believe the NSF has not gone far enough. Robert Atkinson of the Information Technology and Innovation Foundation (ITIF) testified before a US Senate committee in June 2010 that:

> "It's time for federal agencies, and particularly NSF, to focus much more on commercialization and industry partnerships. NSF is almost exclusively focused on providing funding for scientific research to universities and makes little effort to ensure that these results are commercialized and lead to jobs in the United States. Congress can play a key role in spurring more industry partnerships and commercialization at universities and federal labs. First, as Congress increases science agency budgets, ITIF recommends that programs that focus specifically on industry partnerships and technology commercialization should receive a large share of the increases. Second, Congress should consider requiring NSF to tie funding to universities to the extent the latter work closely with industry and commercialize technology. Third, Congress should consider creating a new program to support university, state, and federal laboratory technology commercialization initiatives, funded by a small "tax" levied on federal research (the way SBIR and STTR are funded). Finally, we encourage Congress to expand R&D tax credit generally and also the scope of the current collaborative R&D credit. should consider requiring NSF to tie funding to universities to the extent the latter work closely with industry and commercialize technology." (Atkinson, 2010: 1-2).

NSF grant conditions

There is a long history of debate over, and revision to, NSF research award criteria. In 1981, the National Science Board (which provides policy direction to the NSF) adopted four generic criteria for the selection of research projects: (1) research performance competence, (2) intrinsic merit of the research, (3) utility or relevance of the research, and (4) effect of the research on the infrastructure of science and engineering. In 1997 the NSF Board replaced these four criteria with two criteria:

- what is the intellectual merit of the proposed activity? and,
- what are the broader impacts of the proposed activity?

In 2007 the NSF issued a special notice on the application of the "broader impacts" criterion and explained that: "Experience shows that while most proposers have little difficulty responding to the criterion relating to intellectual merit, many proposers have difficulty understanding how to frame the broader impacts of the activities they propose to undertake."(USG, 2007a). The notice places considerable emphasis on "collaboration" between researchers and other sectors, including industry.

NSF funding award criteria have drawn the attention of the US Congress. The final 2007 NSF reauthorization authority states that:

> "(a) IN GENERAL.—Among the types of activities that the Foundation shall consider as appropriate for meeting the requirements of its broader impacts criterion for the evaluation of research proposals are partnerships between academic researchers and industrial scientists and engineers that address research areas identified as having high importance for future national economic competitiveness, such as nanotechnology."(US PL 110–69).

In 2010 the NSF broader impacts review criterion again drew US Congressional attention. Section 601 of the *America COMPETES Reauthorization Act of 2010* states that the NSF's broader impacts review criterion shall achieve a variety of goals, one of which is "Increased partnerships between academia and industry." (USG, 2010i).[112]

NSF funding programs to encourage U-B collaboration

Apart from the general criteria the NSF applies to the award of research grants discussed above, the NSF has a range of funding programs specifically targeting U-B collaboration. Three examples are:

- **NSF Engineering Research Centres (ERCs).** At the request of the White House and the US National Academy of Engineering, the Engineering Research Centers Program was established at the National Science Foundation

[112] This legislation was passed in identical form in both the House (May 2010) and the Senate (December 2010) as was signed into law by the US President on January 4, 2011.

in 1984 as a national priority to strengthen the competitiveness of U.S. industry. As reported in May 2010 by the director of the one of the ERCs:

> "The goal was to establish centers that would develop a new interdisciplinary culture in engineering research and education in partnership with industry. Together they would advance knowledge and technology and educate new generations of engineers who understand industrial practice and the process of advancing technology, design, and manufacturing, thus ready to work productively in industry upon graduation. As a result three generations of ERCs were established, 49 in all, between 1985 and 2006. … They formed partnerships with thousands of firms that helped focus the research on useful and transformative technologies and prepare graduates for successful careers as leaders in industry and academe. Education programs provided a mentored, interdisciplinary research experience for undergraduates and graduates and introduced pre-college teachers and their students to engineering concepts to stimulate interest in careers in engineering." (USG, 2010q: 1).[113]

The U-B collaboration elements of the ERC program have been subject to criticism. For example, in response to the Obama Administration's 2010 request for views on the commercialization of federally funded university research (discussed earlier in this paper), over 50 organizations (representing a wide range of university and private organizations with an interest in technology transfer issues) stated that:

> "If the Administration hopes to make the ERCs a focus of technology commercialization, then the program needs to change its orientation from "considering" the opinions of industry representatives to placing industry in charge of determining the research agenda. Industry as the lead in setting the research agenda is the model that most state-funded university-industry research centers follow." (State Science and Technology Institute, 2010a: 8)

The US Administration's FY 2011 budget request asks for US$ 67.5 million for funding of ERCs.

- ***NSF Industry/University Cooperative Research Centers (I/UCRC).*** The I/UCRC was established by the NSF in 1973.[114] Each center is established to

[113] Since 2006 the NSF has developed five new ERCs.

[114] The I/UCRC program was launched in 1973 through pilot centers at Massachusetts Institute of Technology, North Carolina State University, and MITRE Corporation. These experimental centers provided the basis for the launch of a permanent UICRC program in 1978 (Bell, 1996).. The program was introduced at the urging of Dr. Richard C. Atkinson who was subsequently appointed NSF Director in 1977. As previously mentioned in this report, Dr. Atkinson was later to inspire San Diego's CONNECT organization during his terms as Chancellor of the University

conduct research that is of interest to both the industry members and the center faculty. (USG, 2009*l*: 2). A proposed centre must meet various criteria to be eligible for NSF seed-funding, including: develop a partnership among university, industry, and other organizations participating in the center; and have industry support that provides the primary financial resources for the center. Today there are over 40 centers involving 118 universities and over 500 industrial firms, along with state governments, national laboratories, and other federal agencies.

Between its launch in 1973 and through to the 1990s, the primary focus of the I/UCRC program was on single disciplinary centres at single universities and on domestic research collaborations. Over the past decade the program has evolved to cover multi-universities and multi-disciplines. In addition, today's NSF solicitations for I/UCRC's encourage international partnerships. The NSF's FY 2011 budget request for I/UCRC funding is US$ 7.85 million.

- **NSF Partnerships for Innovation Program.** The *America COMPETES Reauthorization Act of 2010* provides that the Director of the NSF shall: "…carry out a program to award merit-reviewed, competitive grants to institutions of higher education to establish and to expand partnerships that promote innovation and increase the impact of research by developing tools and resources to connect new scientific discoveries to practical uses." To be eligible for funding under this section, an institution of higher education must propose establishment of a partnership that includes at least one private sector entity. In FY 2011 the NSF plans to make up to 11 awards totaling approximately US$ 7 million. Awards may be up to US$ 600 thousand with award durations of two or three years.

National Institutes of Health Research Grant Conditions and Funding Programs

The Department of Health and Human Services (HHS) is the main federal source of funding for health-related R&D. in FY 2008 its R&D obligations[115] were US$ 29.7 billion, or 26 percent of all federal R&D. Over 90 percent of HHS R&D funding flows through the National Institutes of Health (NIH). (USG, 2010s: C4-25).

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of California, San Diego between 1980 and 1995.

[115] In the US, the three main R&D funding terms are: R&D budget authority and appropriations (budget authority is the legal authorization to expend funds. Budget authority is most commonly granted in the form of annual appropriations by Congress); R&D obligations (orders placed, contracts awarded, services received, and similar transactions during a given period, regardless of when the funds were appropriated and when the future payment of money is required); and R&D outlays (checks issued and cash payments made during a given period, regardless of when the funds were appropriated or obligated (American Association for the Advancement of Science, 2010, Web).

Earlier in this report it was noted that funding programs directly targeted at supporting research commercialization by the Canadian Institutes for Health Research (CIHR) are relatively few in number and small in resourcing (relative to the CIHR's overall budget). This is also the case with the US National Institutes for Health and perhaps for similar reasons: the U-B relationship in this area is mediated and shaped not so much by funding conditions (although of course federal funding is important for the conduct of research by extramural performers) as by the regulatory environment (e.g. rules respecting the conduct of clinical trials; the US Federal Food and Drug Administration's regulatory regime for safety and efficacy of drugs, and the intellectual property regime); and the US bio-medical-pharmaceutical industry requires little incentive to collaborate with universities or affiliated hospitals.[116]

In 2003 the NIH announced a series of initiatives intended to "speed the movement of research discoveries from the bench to the bedside" and that may also encourage U-B collaboration although not as a stated objective. For instance, the NIH Clinical and Translational Science Centres program was established in 2006 and funds 46 academic health centres (US$ 500 million annually). These centres conduct translational research, sometimes in partnership with industry.

The major NIH funding awards more directly targeted at encouraging U-B collaboration are provided through the NIH version of the congressionally mandated Small Business Innovation Research (SBIR) program and Small Business Technology Transfer (STTR) programs. The NIH (along with most other US federal R&D performing agencies) is required to set-aside 2.5 percent of its extramural R&D budget for making awards to small business under SBIR and 0.3 percent of its extramural R&D budget under STTR. For the NIH, this represented funding allocations of US$ 672 million in FY '09 (USG, 2009:12 OER). (The next section of this report includes a description, from a U-B collaboration perspective, of the impact of the SBIR and STTR programs).

5.4.2 Other Federal and State Government Funding Programs

The role of US governments as funders of U-B collaboration should be considered from two perspectives. From one perspective, the quantity of resources represented by federal programs that are directly targeted at encouraging U-B collaboration appears quite small (the main federal programs have been described in the preceding section).[117] But a broader perspective should also be taken. The quantity of financial resources spent by the US federal government (and also by some state governments), and how it is spent

[116] The longstanding intensity of the relationship between the US life science industry and universities is well-illustrated by survey results reported by Zinner et. al. (2009). Their 2007 survey of 3,080 US academic life science researchers found that 52.8 percent of respondents had some form of relationship with industry.

[117] By some estimates there are over 1,700 state level programs to support "economic development" and how many of these may be targeted at encouraging U-B collaboration remains a subject for future research.

through a “triple-helix” (government-industry-university) of funding relationships fundamentally shapes and influences U-B collaboration in the US. Arguably this is also the case in many other national jurisdictions. However, even if only as a matter of degree, and as is shown through all but one of the following examples (funding for “cluster” development), it is a more visible feature in the US than other countries.

Advanced Research Projects Agencies (Energy and Defense)

The US National Academies of Sciences’ landmark 2005 report, *Rising Above the Gathering Storm*, included a recommendation to create in the Department of Energy an organization like the Defense Advanced Research Projects Agency (DARPA) called the Advanced Research Projects Agency-Energy (ARPA-E). The US Congress authorized the establishment ARPA-E within the Department of Energy in 2007. Initial funding (US$ 400 million) was approved by the US Congress in 2009. ARPA-E and DARPA (established in 1958) have very different missions but both promote the translation of basic research in high risk areas to practical application. The US Administration’s 2011 budget request for DARPA is US$ 3 billion and, for ARPA-E, US$ 300 million.[118]

Both DARPA and now ARPA-E are seeking to develop the supporting circumstances for U-B collaboration through their research spending. For example, in March of 2010 the Director of DARPA, Dr. Regina Dugan, stated that:

> “DARPA is not a pure science organization, but neither are we a pure application organization. We sit firmly at the intersection of the two and, to be successful, we need the minds of the basic scientist and the application engineer, those in universities, and those in industry. And we need them working together, often on a single project, in the cauldron created by the urgency and technical demands of Defense. This is almost a unique characteristic of DARPA projects, which are often multi-discipline, multi-community, and multi-stage.”(USG, 2010w: 16).

US Department of Energy (DOE) Joint BioEnergy Institute

In 2007 the US DOE established three US bioenergy research centres with funding up to US$ 375 million. One of these is the Joint BioEnergy Institute (JBEI) which has a five-year research program focused on converting cellulosic biomass to advanced biofuels. JBEI is a six institution partnership led by Lawrence Berkeley National Laboratory and including the University of California (Berkeley), the University of California (Davis) and the Carnegie Institute for Science. It is based in the San Francisco Bay Area.

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[118] On July 22, 2010, The Senate Appropriations Committee approved the *Energy and Water Development and Related Agencies Appropriations Act, 2011* (S.3635) in which ARPA-E funding is cut 33.3% (US$ 100 million) from the request to US$ 200 million). In addition to ARPA-E, the Department of Energy (DOE) established 46 Energy Frontier Research Centres (EFRC) in 2009 involving universities, national laboratories, nonprofit organizations, and for-profit firms, singly or in partnerships. The US Administration’s FY 2011 funding request for the EFRC is US$ 140 million (an increase of US$ 40 million over the FY 2010 appropriations).

The JBEI seeks to create supporting structure for the transfer of JBEI inventions to private industry for commercial development through a formal program for research collaborations with companies. Industry participants are encouraged to:

- serve on JBEI's Industry Advisory Committee (which reviews JBEI research and provides feedback on commercialization opportunities);
- may contribute to post-doctoral fellowships; and,
- may choose to send company researchers to join JBEI researchers and receive training in biofuels research protocols and approaches. (USG, 2009i).

UC Berkeley's expansion into collaborative biofuels research (both through JBEI but also through its Energy Biosciences Institute (EBI – a partnership with BP PLC and the Lawrence Berkeley National Laboratory) occurred even as the repercussions of UC Berkeley's controversial 1998 collaborative research agreement with Novartis Agricultural Discovery Institute reverberated.[119] In 2008, and after an external review of the issues raised by the Novartis agreement, a UC Berkeley Senate task force developed *Principles and Guidelines for Large-Scale Collaborations between the University and Industry, Government, and Foundations*. The task force reported that:

> "While, in principle, publicly-funded research might be thought to reflect a greater convergence of interests between the University and the sponsor, with the public good as the aim on both sides, public funding is decided by individuals in public institutions which may deviate at times from the public good objectives, and industry funding may lead in specific cases to projects that are important to achieve the public good. …We learned during our investigation that in many cases there are more "strings" attached to government funding than industry funding, rendering false any presumption that industry-sponsored research is more restrictive." (University of California, Berkeley, 2008: 3)

[119] In November 2008, UC Berkeley (UCB) entered into a five-year US$ 25 million contract with Novartis for the conduct of plant technology research. A subsequent external review of the agreement commissioned by UC Berkeley found that: "While the implementation of the agreement has been relatively uncontested and many of the critics' worst fears did not occur, the fact that the agreement was widely challenged is important on a number of levels. The controversy over the agreement is informative in that it sheds light on some of the larger issues and contested transformations taking place in higher education and, more specifically, at UCB. …In responding to our questions, interviewees proposed a number of reasons for why the agreement was controversial. The reasons can be divided into four broad groups: (1) issues relating to the process by which the agreement was created and signed, (2) the substantive content of the agreement, (3) local conditions at UCB and in the Bay Area, and (4) broader issues that reflect the changing character of the university." (Michigan State University, 2005: 45).

US National Nanotechnology Initiative (NNI)

The NNI was announced in January 2000 by the Clinton Administration and authorized by the US Congress through the *21st Century Nanotechnology Research and Development Act of 2003*. NNI is premised on the creation of a "grand coalition" of academe, government (25 different federal agencies), industry and professional groups. (Roco, 2007). Encouraging U-B collaboration is embedded in the design of the NNI through:

- management arrangements (e.g., the NNI's working group for Nanomanufacturing, Industry Liaison, and Innovation is composed of government, industry and university representatives and is mandated to create mechanisms to facilitate nanotechnology innovation and to improve technology transfer to industry);

- co-location of major research facilities and infrastructure with major research universities, national laboratories, and private sector companies (almost all of the NNI's 60 research facilities are located on or adjacent to a major university campus); and,

- conditions and mechanisms of access to research infrastructure (e.g., through the National Nanotechnology Infrastructure Network, the National Nanomanufacturing Network, and the Nanoelectronics Research Initiative).

The US President's Council of Advisors on Science and Technology (PCAST) undertakes regular reviews of the NNI. In 2010 it recommended that the US federal government should expand its funding commitment in nanomanufacturing and commercialization based on the model of U-B collaboration represented by the Nanoelectronics Research Initiative. The Nanoelectronics Research Initiative (NRI) is a consortium of semiconductor companies and is operated through 30 university-based centers. The US Semiconductor Research Corporation (previously described in section 5.3.1.2 of this report) is one of the intermediary organizations being used to implement the NRI. The Obama Administration's proposed FY 2011 budget for National Technology Initiative is US$ 1.8 billion.

A number of US state governments have their own nanotechnology funding programs in place that are formally and informally linked to the broader NNI. As reported by PCAST:

> "At the level of individual States, nanotechnology is vibrant and active. Today, some 25 States have their own nanotechnology programs. Most State efforts leverage Federal NNI-supported research by emphasizing translational research and development aimed at state and regional job creation by the private sector. Among the most ambitious of these is the College of Nanoscale Science and Engineering at the State University of New York, Albany. With New York State assistance, the College has built infrastructure consisting of 800,000 square feet of shared new facilities for public-private partnerships. More than a dozen

> companies involved in the development of nanoelectronics technologies now use this facility."(USG, 2010o:19).

The Small Business Innovation Research (SBIR) program and the Small Business Technology Transfer (STTR) program

The Small Business Innovation Research (SBIR) program was authorized by the US Congress in 1982. Subject to periodic reauthorizations, the program directs federal agencies that award more than US$ 100 million in R&D contracts annually to set-aside a proportion (originally 1.25 percent and now 2.5 percent) of their extramural R&D awards to small businesses.

The legislative objectives of SBIR do not include encouraging U-B collaboration, but rather the stimulation of technological innovation in the small business sector, meeting the R&D needs of the government, and expanding commercialization of the results of federally funded R&D. However, in implementation SBIR has been an important instrument for encouraging U-B collaboration.[120] In 2008 the US National Research Council (NRC) reported to the US Congress that:

> "SBIR is increasingly recognized as providing a bridge between universities and the marketplace. In the NRC Firm Survey, conducted as a part of this study, over half of respondents reported some university involvement in SBIR projects. Of those companies, more than 80 percent reported that at least one founder was previously an academic. SBIR encourages university researchers to found companies based on their research. Importantly, the availability of the awards and the fact that a professor can apply for an SBIR award without founding a company, encourages applications from academics who might not otherwise undertake the commercialization of their own discoveries. In this regard, previous research by the NRC has shown that SBIR awards directly cause the creation of new firms, with positive benefits in employment and growth for the local economy. Of course, not all universities in the United States have a strong commercialization culture, and there is great variation in the level of success among those universities that do." (USG, 2008: 42-47)

SBIR has been characterized as a massive government venture capital support program (Cumming, 2007). However, there are limits to the participation of larger venture capital investors. As explained by the US Biotechnology Industry Organization in November 2010:

> "In 2003, the Small Business Administration ruled that companies that have more than 51 percent ownership by outside investors would have to count the employees of the outside investor's company toward the 250 employee limit for

[120] Eligibility for many US procurement preference programs for small business, including the SBRI program, is subject to a large body of regulation, including size standards. Achieving a balance between targeting programs for small and medium sized businesses and reducing program complexity to a minimum remains a challenge in the US and other jurisdictions.

> small business eligibility. The ruling eliminated eligibility for companies backed by large venture capital firms, including many biotechnology companies participating in the SBIR program at the National Institutes of Health (NIH) …Reauthorization of the program has been in flux in Congress recently because negotiations for a compromise on the issue of VC-backed companies ended without agreement. …it was hoped that a compromise could be reached to reauthorize the program for another eight years. The proposed agreement would have allowed VC-backed companies to once again compete for SBIR research grants. (Biotechnology Industry Organization, 2010: 1).[121]

The US Congress also established, in 1992, the Small Business Technology Transfer (STTR) program. It is subject to periodic reauthorization, and provides that US federal agencies with extramural R&D budgets over US$ 1 billion to direct a proportion (originally .15 percent and now 0.3 percent) of their applicable extramural R&D budgets to small business and non-profit research institutions.

In contrast to the SBIR program, the STTR program requires research partners at universities and other nonprofit research institutions to have a formal collaborative relationship with the small business concern. At least 40 percent of the STTR research project is to be conducted by the small business concern and at least 30 percent of the work is to be conducted by the single, partnering research institution (usually a university). The STTR program is small in financial scale relative to the SBIR program. Over the period FY 1994 to FY 2006, STTR awards totaled US$ 1.3 billion while SBIR awards totaled just under US$ 17 billion.

The Technology Innovation Program (TIP)

This federal program, authorized through the *America COMPETES Act* (2007) and administered by National Institute of Standards and Technology (NIST), funds high-risk, high-reward research in areas of critical national need. TIP's predecessor program, the Advanced Technology Program (ATP), was accessible by firms of all sizes and this became one of its political vulnerabilities (the ATP was terminated in 2007). In contrast, TIP is targeted at SMEs. Large companies are not eligible. Single company projects can be funded up to US$ 3 million over a maximum of three years while joint venture projects (those involving two or more for profit companies or at least one for-profit company and a university or other research institution, including a national laboratory) can be funded up to US$ 9 million over a maximum of five years. By law, TIP's advisory board must include a majority of members from industry (USG, 2009n: 1). As of November 2010, there were 28 active and funded TIP projects: eight were being led by

[121] In December 2010 the US Senate approved by unanimous consent legislation to reauthorize the Small Business Administration's Small Business Innovation Research (SBIR) and the Small Business Technology Transfer Research (STTR) programs through 2018. However, the House did not act on the measure before adjourning. The bill would have made firms majority owned and controlled by multiple venture capital firms eligible for up to 25 percent of the SBIR funds at NIH, NSF, and the Department of Energy and up to 15 percent of the funds at the other eight agencies.

US universities and four others included US university participation. (NIST TIP Project Database Accessed November 2010).

President Obama's FY 2011 budget included a request to increase TIP's budget from for a US$ 79.9 million to US$ 89.9 million. NIST anticipates the program's budget will rise to an eventual level of US$ 100 million by FY 2015.

US State and Federal Funding for Cluster-based Economic Development

In 2001 the US National Governors Association (NGA) launched a major policy research initiative on state economic competitiveness. This work culminated in July 2002 with the publication of a series of economic policy papers, including *A Governor's Guide to Cluster-Based Economic Development*. The guide admonished that:

> "Policymakers should remember that clusters are bred, not constructed. Most of the world's successful clusters have evolved through a serendipitous string of events but with strong roots in place. Public policies may have been catalysts for growth, but usually inadvertently and rarely with the intent of starting a cluster. The growth of the largest clusters has been driven by market demand and entrepreneurism."(National Governors Association, 2002: 26).

Apparently this admonishment did not apply to the State of Michigan. In July 2002, the then Governor of the State of Michigan and Chairman of the NGA, John Engler, endorsed the Governor's Guide to Cluster-Based Economic Development. Just three months earlier he had announced his state's support for the development of NextEnergy, a Michigan-based cluster for the research, development, commercialization and manufacture of alternative energy technologies. Doug Rothwell, then president of Michigan's Economic Development Corporation, testified before the U.S. House Subcommittee on Energy in June 2002 that:

> "NextEnergy is a comprehensive set of actions and incentives designed to position Michigan as a center for alternative energy technology research and development, education and manufacturing. …The first major component of the NextEnergy initiative will be the NextEnergyZone, approximately 700 acres of prime real estate that the state is contributing towards this effort. The site is located near Ann Arbor, strategically near the University of Michigan and Detroit Metropolitan Airport. Funds will be dedicated for necessary site improvements, construction of incubator space and development of an alternative energy microgrid to power the entire site with new energy systems such as fuel cells. Any company within the NextEnergyZone will operate virtually free of all state and local taxes. The state will also provide a refundable Single Business Tax Credit for companies located within the Zone based on the number of employees they hire.
>
> The core of this Zone will be the NextEnergy Center, a campus composed of laboratory facilities, business incubator space, collaborative meeting space and

> other facilities that will support the alternative energy industry. …Among other things the Center will facilitate and fund industry-university collaborative research and commercialization projects, develop industry support services and develop higher education and technical degree programs in alternative energy enabling technologies.
>
> We will also establish a Michigan NextEnergy Development Fund to seed venture capital funds, provide working capital and/or finance the construction of research, development and manufacturing facilities for alternative energy companies. By this means we will be able to provide key, targeted assistance to startup companies and others who are working toward the commercialization and production of alternative energy products." (Rothwell, 2002: 13-15).

Further evidence that the 2002 Governors' Guide Cluster-Based Economic Development was divorced from the reality of US state economic development policies is found in the NGA's 2007 policy statement, *Innovation America*. This statement says that state governments have a clear role to play in developing clusters:

> "Because innovative, fast growing companies typically locate near state assets such as universities and transportation centers, it is the proper role of government to assist in accelerating innovative economies. It is also possible for two or more states to enhance the assets of a region that adjoins common borders or even coordinate strategies to assist the entire region. A prime example for a multi-state high growth region is the Route 128 corridor in New England, where education assets near Boston and high-tech businesses along the corridor fuel job growth in Southern Vermont, New Hampshire and Rhode Island."(National Governors Association, 2007: 3).

The Obama Administration supports cluster policies as one element of a broader urban policy agenda and also as part of its 2009 *A Framework for Revitalizing American Manufacturing*. The Administration's FY2010 Budget proposed US$ 50 million in regional planning and matching grants within the Economic Development Administration (EDA) to support the creation of regional innovation clusters.

According to the US Assistant Secretary of Commerce for Economic Development, John Fernandez, the regional innovation clusters initiative is not a specific budget program but represents an important strategic framework to guide "overall programmatic investments." Actual investments supporting regional innovation clusters cut across several Economic Development Administration (EDA) programs. (USG, 2010v). In 2009, Fernandez testified before the US Senate Committee on Commerce, Science and Transportation that the EDA will use some portion of its US$ 50 million in regional innovation cluster funding to support science parks.[122] He explained to the Committee that:

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[122] Fernandez provided the following examples of EDA financial support for US science parks: US$ 3 million for the Sandia Science and Technology Park in New Mexico; US$ 4.7 million for the Arizona Bioscience Park in Tucson; and the Virginia Tech University Institute for Advanced

> "U.S. universities provide the base for new industries and jobs of the future, but discoveries alone are not enough to form these industries. This is where science parks come in. Specifically, these types of science parks are seen by many as an effective policy tool to realize larger and more visible returns on a nation's investments in research and development by bringing together established technology companies, technology incubators, and world-class universities. The intent of science parks is to encourage greater collaboration among universities, research laboratories, and large and small companies, in order to facilitate the conversion of new ideas into innovative technologies for the market. They are widely used as a tool to encourage the formation of innovative high-technology companies, generate employment, and make existing companies more competitive through cooperative R&D, shared facilities, and the benefits derived from co-location. Science Parks are a rapidly growing phenomenon and an increasingly common tool of national and regional economic development. …There are many examples of successful science parks across the nation, and EDA is proud to have played a role in their development. (USG, 2009m: 3-7)

5.4.3 Other Fiscal Incentives

The US Congress first passed a "Credit for Increasing Research Activities" in 1981. It has expired on one occasion (1985) but has been reenacted on numerous occasions. For over twenty years various US Administrations have asked the US Congress to make the tax credit permanent (USG, 2009n). In September 2010, US President Obama issued a proposal to expand research tax credit by about 20 percent, simplify the credit, and make it permanent (USG, 2010c). There are also a diverse array of state-level research tax credits, a number of which are designed to encourage U-B research collaboration.

The Federal Government's Basic Research Tax Credit

The existing US federal research tax credit is available for: qualified research expenses; certain payments to Energy Research Consortia; and for Basic Research Payments. The last of these, commonly called the Basic Research Credit, was introduced in 1986. In essence, it created and defined an additional category of eligible R&D expenses under the US federal R&D tax credit. As described by the US Congressional Research Service:

> "A primary aim of the credit is to foster collaborative research between U.S. firms and colleges and universities. The credit is equal to 20 percent of total payments for qualified basic research above a base amount, which is known as the "qualified organization base period amount. …The credit does not apply to qualified basic research done outside the United States, or to basic research in the social sciences, arts, or the humanities. In addition, the basic research credit applies only to payments for qualified basic research performed under a written contract by the following organizations: educational institutions, nonprofit

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Learning and Research in Danville ("Virginia Tech established a branch of the University in this very rural area near the North Carolina border. The regional economic impact of this science park may be felt well beyond the state line") (Fernandez, 2010: 5-6).

> scientific research organizations (excluding private foundations), and certain grant-giving organizations." (USG, 2008e:10).

In 2008 PCAST recommended improvements to the US federal R&D tax credit, in part because of its affect on U-B research collaboration:

> "While continuing to support actions that would ensure greater permanency for this vital tax credit, PCAST also recommends other modifications to improve the credit. …Providing increased incentives for supporting basic and discovery research versus more applied research could also stimulate support for higher risk innovative research programs. This change could provide an additional, very important incentive to further stimulate university-industry collaborations. The Administration should continue to work with Congress to implement comprehensive changes to the R&D tax credit." (USG, 2008f: 28).

The Qualified Therapeutic Discovery Tax Credit (available for 2009-2010 only)

In 2010, and as part of the *Patient Protection and Affordable Care Act*, the US Congress authorized *The Qualified Therapeutic Discovery Project (QTDP) Program.* Under this program, tax credits, or grants in lieu of credits, were provided to eligible small firms. A central feature of the QTDP credit was that the US government (through the Department of Health and Human Services (HHS) and the US Internal Revenue Service (IRS)) determined which projects would be eligible based on a project's potential to: result in new therapies; treat areas of unmet medical need; prevent, detect, or treat chronic or acute diseases and conditions; reduce long-term health care costs in the US; significantly advance the goal of curing cancer within the 30-year period beginning on May 21, 2010; have the greatest potential to create and sustain (directly or indirectly) high quality, high-paying jobs in the United States, and advance United States competitiveness in the fields of life, biological, and medical sciences.

The US HHS reports that 2,923 companies were awarded funding under the QTDP (USG, 2010t). Precisely how many of the funded projects are being conducted in collaboration with US universities and research hospitals is not known. However, a cursory scan of the companies awarded funding - via QTDP credits or grants - reveals that many have strong formal or informal relationships with US universities and research hospitals.[123]

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[123] Three among many examples are: Questcor Pharmaceuticals, a California-based biopharmaceutical company which provides financial support for innovative medical research at major academic institutions; Accord Biomaterials Inc, a company founded in 2008 to develop and commercialize biomedical technology invented at the University of Michigan and which received venture capital funding from the University of Michigan's Wolverine Venture Fund; and DNAtriX, Inc., a biotechnology company based in Houston Texas and is which is collaborating with the University of Texas MD Anderson Cancer Center on clinical trails for certain cancer therapies. QTDP grants (but not tax credits) were also awarded to three foreign owned companies with US operations, one of which was Canadian: Enobia Pharma Inc. Enobia is based in Montréal Québec. Enobia's Vice-President & Chief Scientific Officer is Dr. Philippe Crine, a professor of

The journal *Nature* presciently reported in June of 2010 that: "For now, the [QTDP] credit is only mandated to cover costs incurred in 2009 and 2010, but it's a safe bet that the industry will lobby for the programme's renewal. Even so, the credit is unlikely to solve the real challenge facing the sector: how to sustain a high-risk industry that often takes a decade or longer to generate a viable product." (Ledford, 2010: 855). In January of 2011, the president of the US Biotechnology Industry Organization (BIO), Jim Greenwood, stated that renewal of the QTDP was a top BIO priority for 2011:

> "The Therapeutic Discovery Project (TDP) program, enacted in 2010, is an example of the type of policies necessary to spur continued medical innovation, while at the same time protecting and growing high-paying U.S. jobs. The TDP program provided $1 billion in research grants and credits for small biotech companies pursuing new therapies for diseases such as Alzheimer's, HIV/AIDs, Parkinson's and MS. BIO is now calling on Congress and the Administration to work together to extend and expand the Therapeutic Discovery Project to support continued American innovation and further accelerate the development of life-saving cures." (Greenwood, 2011)

State Government Tax Credits to Encourage U-B research collaboration

Several US states have also introduced tax credits explicitly designed to encourage U-B research collaboration within their jurisdictions. For example, the state of North Carolina offers business a 20 percent tax credit based on eligible expenses with North Carolina universities and, effective January 1, 2011, will permit digital media companies to be eligible for a 20 percent tax credit based on allowable expenses paid to a participating North Carolina community college or a research university. (Government of the State of North Carolina, 2010, Web, accessed January 2011). Paff and Watkins (2009) point out that: "…several states provide a significantly higher credit rate for external contract research. For example, in 2002 California's external contract research credit was 24% with a QRE [Qualified Research Expenditure] rate of 15%; in Massachusetts the rates were 15% and 10%... This suggests state-level policymakers want to encourage firms to increase investment in basic science…" (Paff and Watkins, 2009: 208).

There have also been calls for US state governments in New York and Virginia to create more generous R&D tax credit in part based on the rationale that they can encourage U-B collaboration. In December 2009, the Governor of New York's Task Force on *Diversifying the New York State Economy through Industry-Higher Education Partnerships* recommended:

> "The adoption of a research and development tax credit, to be governed by the following principles: Eligibility for the tax credit should flow automatically

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biochemistry at the University of Montréal Medical School, a former Chairman of the Department of Biochemistry, and former assistant-dean for medical research at the University of Montréal). The full list of QTDP tax credit and grant recipients may be accessed through US HHS website at: http://www.irs.gov/businesses/small/article/0,,id=228764,00.html

> from the existing Federal R&D tax credit to minimize bureaucratic hurdles for both companies and state agencies; and the tax credit should increase for companies collaborating with institutions of higher education located in New York State" (Government of the State of New York, 2009: 41).

The *Final Report* of the State of Virginia's Commission on Economic Development and Job Creation, issued in October 2010, states that:

> "Virginia is one of only twelve states that do not offer a Research and Development (R&D) tax credit. Small research-intensive advanced technology companies often take ten or more years to get a product to market. Tax credits are extremely helpful to provide capital, especially if they are refundable or transferable. …The Commission proposes a Virginia R&D Refundable Tax Credit, equal to 1-6% of the federal credit, scaled based upon the R&D investment, with a special 6% credit for qualified advanced technology start-ups and early-stage firms. **A special incentive (and additional 6-10%) could be added if the research is performed by a Virginia university.** For qualified start-ups and early-stage firms with 50 or fewer employees, the state will refund in cash 65% of the value of R&D credits that cannot be used for lack of tax liability, in lieu of a carry-forward option. The R&D Tax Credit will end Virginia's competitive disadvantage by adding this important incentive tool for advanced technology firms and provide needed capital for technologies invented at Virginia universities that would otherwise never be commercialized, create jobs or add to the tax base." (Government of the State of Virginia, 2010: 6). [emphasis added].

5.5 US Governments as Rule-makers

Examples of the US federal government's role as rule-maker for encouraging U-B collaboration (but often as part of an effort to achieve other and broader policy objectives) are found in the areas of: intellectual property; export controls; immigration and visa laws and policies; and federal and state regulatory regimes for the conduct of research.

5.5.1 Intellectual Property (IP)

The US *Patent and Trademark Act Amendments Act* of 1980 (the *Bayh-Dole Act*) provides US universities, small businesses and non-profit organizations that receive federal R&D funding with the option to retain patents on the inventions they create through that funding. One of the legislative objectives of the *Bayh-Dole Act* is to: "…promote collaboration between commercial concerns and nonprofit organizations, including universities" (35 USC S 200). Many observers have given the US an academy award for the Bayh-Dole Act, with *The Economist* magazine calling it "possibly the most inspired piece of legislation to be enacted in America over the past half-century" and suggesting that "more than anything, this single policy measure helped to reverse America's precipitous slide into industrial irrelevance." (Innovation's Golden Goose, 2002). However, over the past decade one of the underpinnings of Bayh-Dole, that title to IP should be held by universities rather than individual employees, has come under attack.[124]

In 2009, former US Senator Birch Bayh (co-sponsor of the *Bayh-Dole Act*), Howard W. Bremer and Joseph Allen took issue with those who believe the *Bayh-Dole Act* should be amended to encourage individual academics, rather than the institutions in which they work, to commercialize federally funded inventions. [125] They wrote:

> "Experience shows that because most university inventions tend to be embryonic in nature it takes from five to seven years to turn a ''good'' university invention into a commercial product. Consequently, the costs of moving from the research lab into the marketplace can easily exceed investment in the initial research by a factor of 10 or more. In the life sciences arena (where most technology transfer successes under Bayh-Dole have occurred), private sector development can cost between $800 million to $1.3 billion per new drug delivered to the market, while requiring more than 10 years for development and product approval. Even then, there are absolutely no guarantees of success in the marketplace.
>
> Asking companies taking such risks to run all over campus tracking down each inventor attempting to strike a deal is unthinkable, as well as impractical. Such a system puts an enormous burden on the shoulders of already overloaded academic bench scientists. They joined the public sector to advance the frontiers of knowledge, not to negotiate patent licensing agreements, or to have to pay for the preparation and prosecution of patent applications and employ counsel to handle the legalities out of their own pockets. Being unversed in the complexities of technology transfer, they easily could be taken advantage of at the negotiating table or in their efforts to assert such patent rights as they may have acquired." (Bayh et. al., 2009: 1).

[124] As mentioned in Section 2.5.3 of this report, Leydesdorff and Meyer (2009) find that the stimulative effect of the *Bayh-Dole Act* has declined over time. They write: "In our opinion, the reason for this is structural. More universities are nowadays increasingly ranked in terms of their knowledge output, and patents or spin-offs are usually not part of this ranking (e.g., THES, 2008). The nature of the competition among universities is changing, and the incentive to patent has thus withered. International collaborations and coauthorships, for example, have become more important in research assessment exercises than university-industry relations…" (Leydesdorff and Meyer, 2009: 10).

[125] Former Senator Birch Bayh is a partner in the Washington office of Venable LLP. He represented the State of Indiana in the US Senate from 1963 to 1981 and co-sponsored the *Bayh-Dole Act* of 1980 with Sen. Robert Dole (R-Kan.). Howard W. Bremer is patent counsel emeritus at the Wisconsin Alumni Research Foundation in Madison, Wisconsin. Bremer co-authored and negotiated the Institutional Patent Agreements codified by the *Bayh-Dole Act* with both the National Institutes of Health and the National Science Foundation. Joseph P. Allen is president of Allen and Associates, Bethesda, Ohio. Allen was a professional staff member for Senator Bayh on the Senate Judiciary Committee. He later oversaw implementation of the law during his public service career at the U.S. Department of Commerce.

The interest of Birch Bayh and his colleagues in the issue of university/inventor IP ownership was sparked by a case now before the US Supreme Court.[126] As reported by Coston et. al. (2011), the case involves a dispute between Stanford University and Roche Molecular Systems over the ownership of three patents claiming methods for quantifying HIV in human blood samples. A US Circuit Court judgement in the case has been appealed to the Supreme Court. In essence, the Supreme Court has been asked to decide whether a Stanford scientist can unilaterally terminate the university's ownership rights under the Bayh-Dole Act by separately assigning his individual rights to Cetus, a biotechnology company that subsequently transferred its rights to Roche. Through his attorney, former Senator Bayh filed a "friend of the court" (amicus curiae) brief with the US Supreme Court in December 2010 that states:

> "In sum, the language and legislative history of the Bayh–Dole Act are unequivocal. Congress intended to vest title to federally-funded inventions in the hands of those best suited to ensure their efficient commercialization— the research institutions, not their employees. Congress never envisioned that individual inventors would have any rights to assign except those subordinated rights that they might obtain from the funding agency through a multi-step statutory framework. To allow inventors to assert title and transfer it freely would destroy the carefully crafted and finely balanced mechanism that Congress established and that has served the public interest greatly for the past three decades." (Coston, 2010).

Bayh is not alone in taking this view. A number of other briefs *amicus curiae* filed with the court support Bayh's position. For instance:

- **The brief filed on behalf of the US federal government argues that:** "The court of appeals erred in holding that an individual inventor may contract around the Bayh-Dole Act's framework for allocating ownership of federally funded inventions. Under the Act, title to a subject invention vests in the contractor (i.e., the research institution), and the contractor may "elect to retain [that] title." …An individual inventor can obtain title in a federally funded invention only if the contractor declines to take title (or fails to assert its statutory rights as required by the Act) and the government affirmatively authorizes the retention of title by the inventor. … The question presented is important. The Bayh-Dole Act reflects Congress's considered judgment about the best way to ensure that federally funded inventions are made available to the public and to encourage further science and technology research and development in the United States. The court of appeals' decision ignores that judgment and allows the wishes of a single inventor to override the Act's allocation of rights in federally funded inventions. The funds at issue are substantial: the federal government spends billions of dollars per year on science and technology research at United States colleges and universities, small businesses, and nonprofit organizations." (Katyal, 2010: 11)

[126] The US Supreme Court is to begin hearing oral arguments on the case in February 2011.

- **The brief filed on behalf of the Association of American Universities, the Association of University Technology Mangers, the Association of Public and Land-Grant Universities, and the Association of American Medical Colleges, argues that:** "The Bayh-Dole Act… which provides the framework for commercialization of federally funded research at universities, stands as one of the most effective statutes ever passed by Congress. …The consequences of the court of appeals' decision are dramatic. Universities cannot simply rewrite assignment documents with all of their researchers going forward in time, because hundreds of billions of dollars in federally funded inventions will be entering the market during the next 10 to 15 years based on already-executed assignment documents. …Private industry cannot be expected to invest billions of dollars over 10 to 15 years to transform fundamental breakthroughs at universities into commercial products (and jobs) without knowing that title to the inventions is free from reasonable question. Roche will likely urge the Court to wait until the consequences of clouded title are measured and weighed. But delay itself will have a considerable detrimental effect on universities, federal funding agencies, and the U.S. economy. The Court should grant the petition for certiorari and correct the court of appeals' fundamentally flawed decision. (Hallward-Driemeier, 2010: 4-5).

- **The brief filed on behalf of the US National Venture Capital Association argues that**: "The venture capital industry has a significant interest in this case because the Federal Circuit's decision, if allowed to stand, would tend to discourage private investment in the development and commercialization of federally funded research ideas, and to frustrate the business community's collaborative efforts with nonprofit and university recipients of federal funding." (Srinivasan, 2010: 2).

The debate over university/inventor ownership of federally funded IP has spilled beyond the confines of the US Supreme Court. In January of 2010 the editors of the Harvard Business Review (HBR) identified Robert Litan and Lesa Mitchell of the US Kauffman Foundation as producing one of the top ten "breakthrough ideas" for 2010: "Let's allow any inventor-professor to choose his or her licensing agent - university-affiliated or not - just as anyone in business can now choose his or her own lawyer."(Litan and Mitchell, 2010: 52-53). This suggestion drew strong reaction, also published in the HBR, from Arthur Bienenstock, Special Assistant to Stanford University's president for research policy, and from David Korn, Vice Provost for Research, Harvard University:

> "We can only anticipate some of the many adverse consequences that are likely to result from adopting the Kauffman Foundation's proposal. Perhaps of greatest concern would be the serious distraction of faculty members from their primary university obligations to research, teaching, scholarship, and public service, not to mention the rise of even more problematic faculty financial conflicts of interest. The proposal would lead to balkanization of faculty IP portfolios; tangled legal obligations; legal and financial liabilities and almost certainly the emergence of competing commercial technology licensing organizations driven to maximize

> their market share, licensing revenues and profits. Taken together, the proposal reveals a surprising lack of appreciation for the complexities inherent in meeting the multiple missions of the university technology transfer process. …It does not merit being chosen as one of the Breakthrough Ideas for 2010." (Bienenstock and Korn, 2010: 16).

Into this debate in September 2010 waded the US National Academies of Sciences when it issued its report on *Managing University Intellectual Property in the Public Interest*. Among its findings were:

> "Finding 5: A persuasive case has not been made for converting to an inventor ownership or "free agency" system in which inventors are able to dispose their inventions without university administration approval. If evidence is developed suggesting that either approach would be more effective than the current system, other significant practical consequences and policy considerations would have to be considered, such as the potential for conflicts of interest and adverse effects on public accountability.
>
> Finding 6: Nevertheless, proposals to empower faculty and other university-based inventors by giving them ownership or rights to market their inventions independent of university oversight reflect a feeling in some quarters that in the current system of university management, inventor initiative is not sufficiently valued and encouraged. In fact, successful commercialization often depends on active inventor engagement, and, in some cases, their playing a lead role." (US National Academies of Sciences, 2010: 4).

Beyond the controversial IP policy issue of university/inventor IP ownership, the overall thrust of the National Academies' study is to bring greater certainty and commonality of IP processes in university settings. For example, the study endorses a number of the Association of University Technology Managers' "Nine Points to Consider in Technology Licencing" and makes a series of recommendations to improve university IP management. The study sets out a future role for the US federal government, including: clear assignment of federal government oversight responsibilities, perhaps by Executive Order; ensuring consistent implementation of federal technology transfer laws by all federal agencies; and setting up an interagency committee on technology transfer that would, for example, evaluate and develop a government-wide position on any proposed changes to the *Bayh-Dole Act* (National Academies of Sciences, 2010: 12-13).[127]

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[127] The National Academies' report also called for US federal government action in relation to the operation of federal Extramural Invention Information Management System (iEDISON). This electronic system permits the centralized reporting and retrieval of inventions created through federal research funding (all federal grantees and contractors must report inventions made through funding agreements to any federal agency). The National Academies recommended that: "Federal research agencies should reinvigorate the requirement that institutions reliably and consistently provide data to iEdison on the utilization of federally funded inventions, including licensing agreements and efforts to obtain such utilization. Such data should be available for analysis by qualified researchers who agree not to disclose the parties to, or terms of, particular

5.5.2 Export Controls

President Obama launched a review of the US export control system in August 2009 and, in his January 2010 State of the Union Address, linked the review to his administration's National Export Initiative (USG, 2010u). The Administration's plan for reform of export controls includes: a single export control list, a single licensing agency, a single enforcement coordination agency and a single information technology system. US Secretary of Defense Robert Gates stated that the existing system has the effect of discouraging exporters from approaching the process as intended: "Multinational companies can move production offshore, eroding our defense industrial base, undermining our control regimes in the process, and not to mention losing American jobs." (USG, 2010n).

US federal laws restricting exports of goods and technology have been in existence for over half a century and, since 1985, a "fundamental research" rule has been applied. US National Security Directive 189 states that: "It is the policy of this Administration that, to the maximum extent possible, the products of fundamental research remain unrestricted." (USG, 1985: 1). Nonetheless, US export controls can complicate some U-B research collaborations (and US university research life in general) through "deemed export" provisions. It is one of the focus areas for the work of the US University-Industry Demonstration Partnership (UIDP, 2010a: 14). As described by one expert: "Although the Fundamental Research exclusion protects the results of university research, that exclusion does not apply to in-coming, proprietary information—both because the information is not the "results" of the research, and because the information is protected for proprietary reasons." (Bohnhorst , 2010: 4).

The US federal government has adjusted export controls in the past in sectors of commercial interest and to take account of university concerns. It has also acted to reduce the administrative cost and clarify the reach of the export control regulatory regime in relation to some forms of applied research at universities, including those conducted through U-B collaborations. The reforms to US export controls may represent a further step in this policy direction.

5.5.3 Immigration

There is no U-B research collaboration in the US (or any other jurisdiction) in the absence of talented people.[128] From this perspective, US federal government immigration laws and regulations are an important policy instrument for influencing the extent and location of collaborative U-B research (and R&D activities more generally).

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agreements." (National Academies of Science, 2010: 13).

[128] US universities and industry heavily rely on foreign born scientists, engineers and students. With respect to universities, the foreign student population in the US in 2006 earned approximately 36.2 percent of the doctorate degrees in the sciences and approximately 63.6 percent of the doctorate degrees in engineering. (USG, 2010s)

In the wake of 9/11 the US federal government instituted immigration and visa measures that reduced US university and business access to the international pool of highly qualified people. In October 2003, the US lowered its annual ceiling on admissions under its HB-1 visa program (covering most highly skilled occupations). However, universities and academic research institutions were granted unlimited access to HB-1 visas. US federal government agencies have been exercising administrative discretion to relieve pressure on access by US industry to highly qualified personnel.[129] Some US industries have argued that current US immigration policy and administration provides an incentive for them to locate their R&D facilities outside the US and, by implication, collaborate with foreign rather than US universities. For instance, the US Semiconductor Industry Association has said:

> "[Immigration] quotas that have not been updated since 1990 which result in long waits for permanent residence status (i.e., green cards) – deters many of these talented scientists and engineers from remaining in the United States after graduation. In order to fully benefit from this talent pool, U.S. semiconductor firms have established research centers outside the United States where foreign nationals can be employed in a manner that is not subject to U.S. immigration restrictions. Foreign governments have encouraged this trend by providing incentives to U.S. firms to conduct R&D locally, by strengthening their university infrastructure, and by establishing semiconductor-specific manpower promotion programs." (Semiconductor Industry Association, 2009: 3-4).

5.5.4 Regulating Research

U-B research collaboration, particularly in bio-medical-pharmaceutical areas, is influenced by the regulatory environment. Three examples of US federal government activity in this area are: the regulation of stem-cell research; the *Federal Objectivity in Research Regulations*; and the US Food and Drug Administration's Critical Path Initiative.[130]

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[129] For example, in April of 2008 the US Department of Homeland Security (DHS) issued an interim final rule that extended the maximum period of Optional Practical Training from 12 months to 29 months for F–1 students who have completed a science, technology, engineering, or mathematics (STEM) degree and accept employment with employers enrolled in U.S. Citizenship and Immigration Services' E-Verify employment verification program (USG, 2008b).

[130] A fourth and emerging example is US regulation in the area of synthetic biology. In December of 2010 the Presidential Commission for the Study of Bioethical Issues provided 18 recommendations on how the developing field of synthetic biology and related biotechnologies can best maximize public benefits, minimize risks, and observe appropriate ethical boundaries. In its report, the Commission observed that it is "extremely difficult" to distinguish between academic, public, and commercial research in synthetic biology and that, in many ways, drawing this distinction in unnecessary: "This intermingling of academic and commercial research—both basic and applied — provides fertile ground for innovation." (USG, 2010j: 114) In general, the Commission took the view that "restrictions on research, whether by self-regulation among scientists or by government intervention, should limit the free pursuit of knowledge only when the perceived risk is too great to proceed without limit. Restrictions can prevent research harms

5.5.4.1 Stem Cell Research

In March of 2009, President Obama issued an Executive Order on *Removing Barriers to Responsible Scientific Research Involving Human Stem Cells*. The Executive Order states:

> "For the past 8 years, the authority of the Department of Health and Human Services, including the National Institutes of Health (NIH), to fund and conduct human embryonic stem cell research has been limited by Presidential actions. The purpose of this order is to remove these limitations on scientific inquiry, to expand NIH support for the exploration of human stem cell research, and in so doing to enhance the contribution of America's scientists to important new discoveries and new therapies for the benefit of humankind."(USG, 2009f).

Leaving aside the highly charged ethical and political debate surrounding the use embryonic stem cells, the Executive Order, should it withstand legal challenges, represents one of the most significant measures the current US Administration has taken to encourage U-B research collaboration. Kenneth Aldrich, CEO of the California-based International Stem Cell Corporation, is reported to have stated that the Executive Order "… removes the fear on behalf of academic institutions to work with us… It opens up every academic institution in the US as a potential collaborator for us." (Aldrich, 2010).

This example of US federal government rule-making and its impact on the environment for U-B collaboration stands in contrast to rule-making (although perhaps better characterized as funding) undertaken by the State of California. In 2004 California voters passed Proposition 71, the California Stem Cell Research and Cures Initiative. This initiative required the State of California to create a stem cell funding agency, the California Institute for Regenerative Medicine (CIRM), which now has US$ 3 billion in bond funding authority. As of April 2010, US$ 1.1 billion had been committed by CIRM to fund stem cell research at profit and non-profit organizations. CIRM's 2008 Annual Report states that:

> "Announced CIRM programs include substantial funding for biotech companies, alone or in collaboration with academic institutions. In 2009 alone, $60 million is scheduled for Translational Research grants, and $210 million is scheduled for Disease Team grants and loans. In 2009, the Board will address resource allocations, in its strategic plan review, for early human clinical trials." (California Institute for Regenerative Medicine, 2008:2).

CIRM believes that public money attracts private money and that scale and focus in resourcing also attracts talent:

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but also can impede innovation and progress that may itself reduce harms. (USG, 2010j: 144). Nonetheless, the Commission also recommended that the US federal government should conduct a review to see if "the existing patchwork quilt is indeed affording the U.S. public and the environment with adequate protections as the field of synthetic biology advances. (USG, 2010j: 102).

> An annual funding floor with critical scale provides California's research institutions and the California-based biotech industry a long enough period of assured funding to launch new research institutes, departments, and biotech companies. Private capital and public institutional capital markets (including academic, university and non-profit institutions) abhor economic uncertainty. Proposition 71 provides a sufficient long-term assurance of funding and scale to recruit and competitively force the commitment of substantial capital assets (by public and private medical institutions), concurrent with Proposition 71 funding, as the price of meaningful participation in the stem cell revolution." (California Institute for Regenerative Medicine, 2009: 4).

5.5.4.2 Federal Objectivity in Research Regulations

The role of US federal government role in relation to establishing a regulatory regime that impacts on U-B research extends beyond seeking to remove barriers to research such as represented in the case of stem cell research. For instance, Campbell and Zinner (2010) report that:

> "Disclosure has been the usual response to concerns about academic–industry relationships. Current federal regulations require that academic researchers receiving funding from the National Institutes of Health (NIH) or selected other agencies of the Department of Health and Human Services (DHHS) report to their institution any industry relationships valued at $10,000 or more that would reasonably appear to affect the research for which a grant is being sought. Once such a conflict has been reported, institutions are required to reduce, manage, or eliminate it and report their actions to the government." (Campbell and Zinner, 2010: 604).

In May 2010 the US Department of Health and Human Services (HHS) issued a proposal for revising federal regulations applicable to institutions that apply for or seek HHS Public Health Service funding for research (except, notably, for Small Business Innovation Research (SBIR)/Small Business Technology Transfer Research (STTR) Phase I applications). The Notice of Proposed Rule-Making states:

> "Since the promulgation of the [Responsibility of Applicants for Promoting Objectivity in Research] regulations in 1995, biomedical and behavioral research and the resulting interactions among Government, research institutions, and the private sector have become increasingly complex. This complexity, as well as a need to strengthen accountability, have led to the proposal of amendments that would expand and add transparency to investigator disclosure of significant financial interests, enhance regulatory compliance and effective institutional oversight and management of investigators' financial conflicts of interests, as well as NIH's compliance oversight." (USG, 2010r: 28688).[131]

[131] As summarized by Campbell and Zimmer (2010), the HHS proposals include: lowering the disclosure threshold to US$ 5,000; requiring disclosure to the investigator's institution of all

5.5.4.3 The US Food and Drug Administration (FDA) Critical Path Initiative and the C-Path Institute

The FDA's Critical Path Initiative is its national strategy for transforming the way FDA-regulated medical products are developed, evaluated, and manufactured. The strategy was launched in 2004 through the discussion paper *Innovation-Stagnation, Challenge and Opportunity on the Critical Path to New Medical Products* (USG, 2004: 30). The Critical Path Initiative, while not specifically targeted at encouraging U-B collaboration, is having a foreseen influence on, and consequences for, U-B research collaboration. One example is FDA support and funding through for the Critical Path Institute (C-Path).

As previously mentioned in this report, the C-Path Institute is essentially an intermediary organization between drug companies, universities and – a point that makes it quite different – a regulatory arm of government. The institute has taken a lead role in creating a Predictive Safety Testing Consortium (PSTC). According to the consortium:

> "The tests currently used to determine drug safety are decades old. Not surprisingly, many drugs that appear safe in laboratory tests may be found later to have side effects when large numbers of patients have taken the drug. Conversely, hundreds of promising drugs never see human use because of ambiguous results from these laboratory tests. While companies may develop safety testing methods based on new technology, these are not generally accepted by the FDA as proof of safety because the tests have not been evaluated by a third party. To change this, Critical Path Institute (C-Path) created the PSTC to allow pharmaceutical companies to share and critically examine their internal experience and methods, pool data for more powerful analyses, and ultimately seek scientific consensus on the value and appropriate context of use of these new tests. Data and results from consortium activities will be submitted to the FDA, EMA [the European Medicines Agency regulatory authority], and PMDA [Japan's Pharmaceuticals and Medical Devices Agency] for their formal evaluation; ultimately, results are made broadly available in the public domain. (Critical Path Institute, 2010: 1)

The Predictive Safety Testing Consortium has seventeen corporate members. It has engaged more than 250 industrial and academic scientists.

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relationships, not just those that the investigator decides are related to a given grant; and requiring institutions to determine the relevance of relationships, to develop a management plan for all conflicts, and to share the results of these management plans with the NIH and the public through a public web site.

5.6 Summary Findings

Since at least 1945, US federal government measures to encourage U-B collaboration have been crafted in response to the larger economic and national security challenges it has faced. At the same time, US federal government measures have been deployed within a national innovation system, the sheer scale and intensity of which has not been matched any other country to date.

Beginning in the late 1990s, U-B collaboration became a more central concern for US federal governments. There were a number of reasons for this development, summarized in the landmark National Academies of Sciences' 2005 report *Rising Above the Gathering Storm*. The report found that the age of relatively unchallenged US leadership in science and technology had ended and that: "The importance of sustaining our investments is underscored by the challenges of the 21st century: the rise of emerging markets, innovation-based economic development, the global innovation enterprise, the new global labor market, and an aging population with expanding entitlements." (USG, 2005: C9-2).

Notwithstanding the rise of other "knowledge based economies" around the world, the US has successfully branded itself on the world stage as having distinctive knowledge advantages across a range of frontier technology areas. The extent of U-B collaboration, and US federal, state and local measures taken to encourage U-B collaboration, has been one means the US has employed to achieve this branding success. Of course, branding is one thing and underlying substance is another. A 2010 study of the US "higher education knowledge exchange system", undertaken by the UK's Higher Education Funding Council, expresses reservations on whether the US system's performance matches its reputation.

> "It can be very hard to shake established myths, particularly if they fit into the overall national psyche. In this country, [the UK] one of our big myths is that we are brilliant at research but poor at commercialising that research. Our entrepreneurial American counter-parts in contrast are outstanding at making money. …This latest research paper from PACEC/CBR - 'The Higher Education Knowledge Exchange System in the US' - goes some way towards debunking these myths. US universities play an enormously important part in American society, engaging with their local communities and helping their local areas to develop. And we are just as good at research commercialisation as US higher education, and indeed our academics may have gone further than in the US in embracing the importance of engagement with the economy and society in their core practices. Adding value to the economy and society through knowledge exchange (KE) though is complex and hard work. There are no easy answers, and US universities are looking at good practices from this country, just as much as we are looking for answers from them."(HMG, 2010r: Foreword).

Some US observers have also expressed concern with the US higher education system's performance from a U-B collaboration perspective and a more general "innovation ecosystem" perspective. The US National Academies of Sciences' September 2010 report, *Rising Above the Gathering Storm Revisited: Rapidly Approaching Category 5*, is decidedly pessimistic in tone. The president of the US State Higher Education Executive Officers (SHEEO), Paul E. Lingenfelter, has said that: "While the United States still enjoys a reputation for the world's finest system of higher education, we are in great danger of complacency. Our reputation is based disproportionately on the achievements of students and faculty at our most prestigious, selective, and most generously financed institutions which enroll fewer than 10% of our students." (Lingenfelter, 2010: 1).

Such viewpoints are unduly pessimistic.[132] In February of 2011, the European Commission issued its scoreboard on EU innovation relative to other major jurisdictions, including the US. The report states:

> "The US and Japan are holding their lead over the EU27. The US innovation performance reflects an innovation system characterised by good levels of tertiary education, **good linkages between the public science system and the private sector**, strong private investment in R&D and a successful commercialisation of technological knowledge." (EC, 2011: 5) [emphasis added].

This report's own compendium of US policy measures to encourage U-B collaboration suggests that, to use a Canadian metaphor, US governments are "skating to where the puck will be." In particular:

- since the 1980s the US federal government has provided legislative room (e.g., permissive competition/anti-trust regulation) for the establishment of some intermediary organizations based on industry consortia. In a number of cases the US federal government has provided start-up funding, but not continuing operational funding for these and other intermediary organizations. The US federal government continues to rely on these organizations as conduits for, and managers of, federal funding for research conducted at universities and sometimes co-funded with business. Two examples provided in this report are the Semiconductor Research Corporation and the Critical Path Institute for drug development and research;

- the number of federal programs (and the quantity of resources they represent) directly targeted at encouraging U-B collaboration is relatively small. Even so, programs such as the NSF's University/Industry Cooperative Research Centres program and National Engineering Research Centres program, are evolving to

[132] A 2008 assessment of US S&T global leadership commissioned by the US Department of Defense and conducted by the RAND Corporation found that the US: accounts for 40 percent of total world R&D spending; 38 percent of patented new technology inventions within the OECD; employs 37 percent of OECD researchers; produces 35 percent, 49 percent, and 63 percent, respectively, of total world publications, citations, and highly cited publications; employs 70 percent of the world's Nobel Prize winners and 66 percent of its most-cited individuals, and is the home to 75 percent of both the world's top 20 and top 40 universities and 58 percent of the top 100 (Galama and Hosek, 2008)..

embrace a broader range of universities, disciplines and industry sectors. Of course, a second and broader perspective is that the sheer quantity of financial resources spent by the US federal government for defence, health and, more recently, energy research, and through a vast labyrinth of funding programs, is the defining "measure" to encourage U-B collaboration in the US. From this second perspective, it is far from clear what "lessons" other national governments may draw. No other national jurisdictions spend as large an amount of money or are willing or able to do so in the foreseeable future (and notwithstanding the "China factor" or even given the US fiscal situation);

- In his 2007 memoirs, Alan Greenspan, former chairman of the Federal US Reserve Board, wrote that: "Arguably, the singled most important economic decision our lawmakers and courts will face in the next twenty-five years is to clarify the rules of intellectual property." (Greenspan, 2007: 498). Many observers have delivered an academy award to the US for the *Bayh-Dole Act* of the 1980. The US is now turning its attention to improving IP management processes and structures within universities and the potential role of the US federal government in this effort. A vigorous debate is taking place on whether an inventor or university ownership model should prevail and the US Supreme Court has taken up the issue. In other areas of rule-making activity, the US federal record is not so positive. There are cases where federal regulation of research (e.g. stem-cells) has adversely impacted U-B collaborative research. More generally, national security concerns permeate all areas of public policy in the US, and the policy area of U-B collaboration is not immune. Export control systems have complicated U-B research collaborations in the US and the US federal government is struggling to find the right balance between national security and a liberal environment for the conduct of U-B collaborative research;

- the US is increasing the financial resources it devotes to measuring and reporting on business innovation in general and U-B collaborative research in particular. The US federal government has introduced: an annual survey of business innovation; important technical refinements to its survey of higher education R&D expenditures; and, more broadly, is making a substantial investment in "the science of science policy"; and,

- US governments can draw on long established forums that bring together university and business leaders to address common issues and advance their respective interests (e.g. the Business Higher Education Forum comprised of Fortune 500 CEOs and university and foundation representatives and the US Council of Competitiveness comprised of CEOs, university presidents and labour leaders). US governments do not directly fund these forums, but they do listen to them and are working with them on a number of discrete projects. In addition, the US federal government is re-engaging as an advocate of U-B collaboration, including through establishing the National Advisory Council on Innovation and Entrepreneurship and through such other means as undertaking public consultations of the commercialization of federally funded research.

6.0 The United Kingdom

6.1 Context

There are 116 public universities in the UK. Enrollment in the total higher education sector (full and part time, universities, colleges and other institutions) was 2.3 million persons in 2007-2008. Public funding of universities is delivered through block grants from Higher Education Funding Councils (there are separate funding councils for England, Scotland and Wales).[133] Public funding for university research is delivered through a dual system of support: funding directed to specific research projects (primarily through the UK Research Councils); and through block research grants from the Higher Education Funding Councils.

The UK's main university association (Universities UK) represents 133 member institutions, including and colleges of higher education. The UK's Russell Group of Universities represents 20 major research intensive universities.

The UK organization that brings together university and business leaders is the Council for Industry and Higher Education (CIHE). The CIHE was established in 1986 and modeled on the US Business Higher Education Forum. In addition, the UK's main business organization, the Confederation of British Industry (CBI) has created within its own organization an Inter-Company Academic Relations Group (ICARG). ICARG's primary focus is on the business-academia interface and, according to the CBI: "The group is unique in that it brings together a wide range of business, government and other organisations in order to exchange ideas, network and provide a forum for regular dialogue." (CBI Web, Accessed November 2010).

As illustrated through the following examples, in the post-WWII period through to the early 1990s, UK governments did not consider U-B collaboration as an economic or education policy concern or priority.

- **The UK Research Associations.** These associations were established during the 1930s and 1940s and operated on a matched funding model, with government providing equal funding to industry in support of research and technology programmes. However, as reported by Hauser (HMG, 2010q), many of these Research Associations were established as membership organizations to generate more industrial funding, and only provided services to their member companies.

[133] In October 2010 the UK Government received the report of the Independent Review of Higher Education and Funding chaired by Lord Browne. The report recommended that existing bodies responsible for the higher education system, including the Higher Education Funding Council for England, be replaced by a single Higher Education Council, "charged with looking after students' interests and the public investment in higher education. It will take a more targeted approach to regulation, with greater autonomy for HEIs. The Council will be independent from Government and from HEIs." (HMG: 2010m: 11).

- **The Report on Scientific Man-Power (Barlow, 1946).** This 1946 report to the UK Department of Reconstruction identified a shortage of scientific personnel and recommended an "ambitious programme of university expansion" to be funded by the Exchequer and that would double the number of student places in science and technology by 1955. But as Bocock and Taylor (2003) have written, the failure of UK Labour governments to offer a clear view of post-war development in higher education, together with a deep-seated ambivalence as to the role of technology and vocational education in universities, meant that Barlow's vision was only partially realized.

- **The Anglo-American Council on Productivity (AACP, 1948-1952) and the British Productivity Council (BPC, 1953-1978).** As early as 1944, concerns were expressed by the UK business community respecting the country's productivity performance relative to the US. These concerns, and also US Congressional interest in ensuring that Marshall Plan technical assistance funding to the UK and other European countries was well spent, led to the formation of the AACP in 1948. At the instigation of the UK Chancellor of the Exchequer, the AACP was succeeded in 1953 by the BPC, a tripartite body of government, labour, and industry (but not academia). However, according to Tiratsoo and Gourvish (2006) the primary focus of both the AACP and the BPC was on strengthening UK management and production processes internally within UK firms (one exception being a concern with the state of management training courses offered at universities and other vocational training institutions).

- **The UK University Grants Committee (1919-1989)**. This UK Government advisory committee was responsible for the allocation of funding to UK universities. In general, U-B collaboration was not foremost in mind in the decisions it took. For example, Martyn Clark (2010) reports that, during the 1950s, some UK universities proposals for government investment in computing infrastructure emphasized potential industrial benefits and joint-use. However:

  > "In evaluating the universities' proposals, precedence was given to universities where researchers could make immediate use of a computer. … the UGC [University Grants Committee] declined to view computer engineering as an appropriate focus for the new computing laboratories. Similarly, despite Treasury concerns, research into business applications of computers was rejected. The focus of the laboratories, and of the new discipline of computer science, was therefore scientific and mathematical." (Clark, 2010: 29).

- **Report of the Committee on Higher Education (Robbins, 1963).** The UK Government commissioned Lord Robbins to review the pattern of full-time education in Great Britain and in the light of national needs and resources. The Robbins Report recommended a major expansion of the UK university system, including through granting of university status to Colleges of Advanced Technology, Teacher Training Colleges and Regional Technical Colleges.

However, it was not until after the National Committee of Inquiry in Higher Education (Dearing) reported in 1997 that the UK governments took advantage of this gradual change in perception and more aggressively sought to better align university "supply" with labour market demand.

- **The Teaching Company Scheme and Science Parks**: A number of programs and measures were introduced by the UK Government during the 1970s and 1980s to support technology transfer and mobility of personnel between university and business sectors, but these were small in scale. For example:

  - A Teaching Company Scheme (TCS) was established in 1975 by the UK's Science and Engineering Research Council (and operated through to 2003) to place students in industry settings (usually engineering related) while meeting industry demands for specific types of expertise. The UK government provided £ 90 million to support the TSC over its entire life. During the final years of is existence, and contributing to its demise, the TCS came under criticism for its low profile and lack of scale.

  - The UK's first science park was established in 1970 at Cambridge University and, as reported by today's Cambridge Science organization, it represented the university's response to government pressure on universities to expand its contact with industry. The number and scale of UK science parks slowly expanded through the early 1980s, partly at the urging of Prime Minister Margaret Thatcher. However, the growth of UK science parks stagnated thereafter up until the late 1990s. (Rowe, 2002).

What accounted for the general disinterest by UK governments (at least through to the end of the 1980s) in encouraging U-B collaboration in research or other areas? The so-called "golden age" – or perhaps more accurately, "catch-up age" – of UK and Western European economic recovery and productivity growth in the 1950s through to the early 1970s may have been a factor.[134] The institutional culture of the major UK universities over much of the period may have been another factor. The post-war experience with nationalization may also have played a part (there is a considerable body of empirical research that finds state ownership is associated with low levels of product and process innovation). During much of the 1980s the UK government's priority was getting the state out of the marketplace – a policy direction that may have worked against the introduction of measures for encouraging U-B collaboration. During the Thatcher years, the pursuit of other educational priorities - raising standards in education, improving

[134] Nicholas Crafts and Mary O'Mahony (1999) find that, over the entire post-war period through to 1990, productivity growth in the UK (GDP per person employed) was about one percentage point per annum greater than in the US but the UK started the period at 55 percent of US levels.

access to higher education, and removing local authority control over UK polytechnics – may also have played a role. [135]

Over the past twenty years UK governments have deepened their role as advocates, enablers, funders and rule-makers for encouraging U-B collaboration. What accounts for this development? On July 23, 1997, the report of the National Committee of Inquiry in Higher Education (Dearing) was delivered to the UK Government, just two months after the landslide election victory of the UK's Labour Party under the leadership of Tony Blair.[136] The Dearing Report described the "wider context" for UK higher education as follows:

> "External factors have affected the development of higher education since the Robbins report on higher education in the early 1960s. We judge that external changes will be even more influential over the next 20 years. …Powerful forces – technological and political – are driving the economies of the world towards greater integration. Competition is increasing from developing economies that have a strong commitment to education and training. The new economic order will place an increasing premium on knowledge which, in turn, makes national economies more dependent on higher education's development of people with high level skills, knowledge and understanding, and on its contribution to research. The UK will need to invest more in education and training to meet the international challenge. …However, no public service can automatically expect increasing public expenditure to support it. Higher education needs to demonstrate that it represents a good investment for individuals and society." (HMG, 1997: 16-19).

There were other policy considerations causing UK governments to focus on U-B collaboration as one element of a broader innovation policy agenda. The effort to complete the EU single market by 1992 was one driver for focusing the attention of all EU governments on innovation performance in general and U-B research collaboration in particular. Another consideration was the UK's productivity performance in the 1990s relative to the improvements recorded in the 1980s. A number of UK studies emerged in the 1990s that documented a substantial labour productivity gap between the UK and

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[135] Thatcher recalled in her memoirs that there were two problems for Britain's scientific effort during the 1980s: "First, too high a proportion of government funding for science was directed towards the Defence budget. Second – and reflecting the same approach – too much emphasis was being given to the development of products for the market rather than to pure science. Government was funding research which could and should have been left to industry and, as a result, there as a tendency for the research effort in the universities and in scientific institutes to lose out. I was convinced that this was wrong. As someone with a scientific background, I knew that the greatest economic benefits of scientific research had always results from advances in fundamental knowledge rather than the search for specific applications."(Thatcher, 1993: 639).

[136] The Committee of Inquiry, chaired by Sir Ron Dearing, was appointed by UK Secretaries of State for Education and Employment, Wales, Scotland, and Northern Ireland in May 1996. It was asked to consider how the purposes, shape, structure, size and funding of higher education, including support for students, should develop to meet the needs of the United Kingdom.

comparable countries, especially the US (Crafts and O'Mahoney, 1999, Blondal and Pilat, 1997). The November 1997 pre-budget report issued by then UK Chancellor of the Exchequer, Gordon Brown, stated that: "The level of productivity in the UK has been lower than that in other G7 economies since the early 1970s." (HMG, 1997a). In his 1998 budget, Brown tied the UK's productivity challenge directly to a new innovation policy theme and to the role of UK universities:

> "So to help turn British inventions into success for British businesses, I am announcing today plans for a new £50 million venture capital fund open to all universities. A new university challenge fund that will invest today in the innovative businesses that will create wealth and jobs tomorrow. Encouraging greater R&D investment is also crucial to higher productivity so the Government is today publishing a consultative document indicating a determination to help businesses achieve this." (HMG, 1998).

UK governments have introduced many measures over the past twenty years to encourage U-B collaboration. The election of a minority government on May 6, 2010 has not tempered this interest. The UK Conservative Party's 2010 election manifesto said that a Conservative government would implement many of the recommendations from a report it commissioned from Sir James Dyson on "making Britain the leading high tech exporter in Europe". The Dyson report called for "collaboration, not competition, between universities, companies and not-for-profits." (Dyson, 2010: 5). On May 20, 2010, Prime Minister David Cameron and Deputy Prime Minister Nick Clegg published their full Coalition Agreement in which a commitment is made to consider the implementation of the Dyson Review and which states: "The Government believes that our universities are essential for building a strong and innovative economy. We will take action to create more college and university places, as well as help to foster stronger links between universities, colleges and industries." (HMG, 2010p: 31).[137]

6.2 UK Governments as Advocates

6.2.1 Advocacy Statements and Strategies[138]

The UK Government published over a dozen white papers and reviews of its innovation policy and the UK's innovation performance between 1998 and 2010 - possibly a record

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[137] The Coalition Government's October 2010 Spending Review expands on the commitment to encouraging U-B collaboration. It states: "To develop the [higher education] sector's contribution to economic growth, the Government will reform the Higher Education Innovation Fund to incentivise universities to increase commercial interaction between the research base and business." (HMG, 2010h: 52).

[138] Over the past two decades, UK Government advocacy of U-B collaboration has taken place within the context of its membership in the European Union (EU). The EU's own advocacy of U-B collaboration through the European Commission (EC) has complemented the UK government's advocacy efforts. See Annex I for a summary of EC initiatives and communications.

among all OECD countries. Each of these documents makes substantive reference to the need to strengthen U-B collaboration and primarily in research areas. Examples include:

- **Investing in Innovation: A Strategy for Science, Engineering and Technology (2002).** This paper stemmed from the 2002 UK Treasury-led spending review and states:

    > “Industry’s own efforts to exploit the ideas and skills emerging from the UK science base will be buttressed by continued and growing investment by the Government in knowledge transfer from the science base. Government resources will be sharply focussed on identified gaps in the transfer of scientific knowledge to industry, enabling collaboration between business and universities and forward-looking investment in future ‘disruptive’ technologies. (HMG, 2002: 6).

- **White Paper on Education and Skills - The Future of Higher Education (2003).** This paper from the UK Department of Education and Skills (DES) states:

    > “Higher education in the UK generates over £34 billion for our economy and supports more than half a million jobs. But less than one in five businesses taps into universities’ skills and knowledge. Universities and colleges can play a bigger role in creating jobs and prosperity.” (HMG, 2003b: 6).

- **Report of the Lambert Review of Business-University Collaboration (2003).** Commissioned by the UK Treasury and chaired by Richard Lambert (now Director General of the Confederation of British Industry and Chancellor of the University of Warwick), the review and its final report profoundly influenced the future course of UK government policy. Lambert said in his foreword to the report that:

    > “The biggest challenge identified in this Review lies on the demand side. Compared with other countries, British business is not research intensive, and its record of investment in R&D in recent years has been unimpressive. UK business research is concentrated in a narrow range of industrial sectors, and in a small number of large companies. All this helps to explain the productivity gap between the UK and other comparable economies.”(HMG, 2003a: 1).

    Thirty-one of the Lambert Report’s thirty-three recommendations targeted potential actions governments and universities could take rather than business. The main recommendation requiring direct action by the business sector was that UK business should establish a high-level forum to increase the effectiveness of technical innovation in business in the UK.

- **Ten Year Science & Innovation Investment Framework (2004).** This framework includes the government's response to the Lambert Review and states:

> "The Government's aim for future policy is to create a funding regime that promotes and rewards high quality knowledge transfer, addresses demonstrable funding gaps inhibiting the translation of research and expertise into the market, and further embeds knowledge transfer as a permanent core activity in universities alongside teaching and research." (HMG, 2004a: 76).

- **The Race to the Top: A Review of Government's Science and Innovation Policies (2007).** Conducted by Lord Sainsbury of Turville, this review introduced to the UK the term "innovation ecosystem." The review covered some of the same ground as the 2003 Lambert report but concluded that there was still room to improve the UK's knowledge transfer performance:

> "Though research is of great importance to any innovation ecosystem, little is to be gained from research in universities, research institutes and further education (FE) colleges if there are not strong links between the researchers and industry, and that is why knowledge transfer, and incentives for it, are so important to the business product, process and management issues they face." (HMG, 2007: 23).

- **Innovation Nation (2008).** This White Paper from the UK Department for Innovation, Universities and Skills (DIUS) set out a broad innovation agenda and sets out a role for government as facilitator and enabler:

> "Government is well placed to lead alignment of the innovation system and it sponsors several of the relevant agencies. It will sometimes have to make choices between different societal priorities – between, for instance, the interests of intellectual property rights holders and the interests of follow on innovators. It is well placed to bridge gaps and facilitate connections between, for example, universities, manufacturers, users and regulators." (HMG, 2008f:17-18).

- **Enterprise: Unlocking the UK's Talent (2008).** This policy statement from the UK Department for Business Enterprise and Regulatory Reform and the UK Treasury set out "new framework of five enablers which will inform and structure the Government's enterprise policy in the next few years." In the area of "knowledge and skills", the government stated:

> Government's challenge over the next ten years is to build on investment that has already been made, to foster further and support the development of enterprise skills and knowledge in the wider education system. Alongside this, Government is committed to strengthening the ability of businesses to access the support and skills development they need. The

> Government will develop seamless enterprise education. A further £30million will extend enterprise education from secondary schools into primary and tertiary education. In addition, entrepreneur Peter Jones is working with the Government to launch a National Enterprise Academy (NEA) as a first in a network of enterprise academies. (HMG, 2008b: 6).

- **Higher Ambitions – The future of universities in a knowledge economy (November 2009).** The strategy paper from the UK Department for Business, Innovation and Skills (formerly DIUS) is presented as a framework that:

> "…commits us to consolidating the global excellence of research in our universities. But we will also ensure that we better understand and exploit the ways in which research can make greater economic and social impact. As a developed country we are operating at the knowledge frontier. We no longer have the choice in the globalised world to compete on low wages and low skills. We compete on knowledge – its creation, its acquisition, and its transformation into commercially successful uses. Although universities have a much civic, cultural and intellectual role, they are central to this process." (HMG, 2009b: 3).

The paper also emphasizes the contribution U-B collaboration can make in areas more traditionally associated with teaching and education missions of universities. The then UK Secretary of State for Business, Innovation and Skills, Peter Mandelson, writes in his introduction to the paper that:

> "We welcome the commitments made by business in the CBI's [Confederation of British Industry] recent report on higher education. The role that business people play as members of University Boards of Governors, as members of University Advisory Councils and in influencing course provision through employer led Sector Skills Councils is of great importance and will become greater in future." (HMG, 2009b: 14).

- **UK Council for Industry and Higher Education (CIHE) study on "*Absorbing Research: the role of university research in business and market innovation*" (May 2010).** Although the CIHE is not a government organization, this CIHE study was funded by Research Councils UK (RCUK - the umbrella body for all UK research councils). The study states that:

> "The most important and urgent action required is the need for a joined-up, coherent and consistent communications strategy from RCUK, the Funding Councils and TSB [Technology Strategy Board] about research impact: what it means, who is responsible for achieving it and how to address the key barriers that inhibit university-business collaboration on research. Notwithstanding the guidance issued by RCUK and the Funding Councils to date, this research highlights that there is still some

misunderstanding of the role of university research in contributing to company innovation. Hence a proactive communications strategy should focus on:

- developing a better understanding of the role universities have as supporters rather than drivers of innovation;
- highlighting that it is often companies that generate economic impact and that universities make a crucial contribution to this impact;
- supporting the “gatekeeping” function within institutions to enable boundary spanning activity by academics;
- encouraging opportunity recognition for the application of university research; and facilitating inter-disciplinary research and also developing a better understanding the barriers that prevent it….” (Ternouth et. al., 2010: 13).

- **Strategy for Sustainable Growth (July 2010).** This policy statement, issued by the Department for Business, Innovation and Skills (BIS), emphasizes a need to strengthen the “absorptive capacity” of business for research and that:

  > “In order to maximise our investment, government needs to articulate a long term commitment to research; ensure access to finance for high tech companies; and incentivise business investment in innovation. BIS will continue to support collaboration between universities and businesses; the commercialisation of new technologies; and the building of relationships between institutions and businesses which foster the exchange of new knowledge.” (HMG, 2010: 11).[139]

- **Blueprint for Technology (November 2010).** This policy statement sets out a broad range of actions the UK Government will take to: “send a clear message to innovative technology companies of all sizes, both established and emerging, that

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[139] A report from the Independent Review of Higher Education Funding and Student Finance was delivered to the new Coalition Government in October 2010. The report focusses on the financing of teaching at UK universities and future policy directions for student fees. However, it also reflects the caution exercised by UK governments (or their policy advisors) in encouraging U-B collaboration in teaching and education areas as opposed to research. For example, the review considers but rejects the argument that businesses should be compelled to invest more in higher education through, for example, the tax system with the extra tax receipts hypothecated to the higher education sector. The review states: “The starting point for this argument is absolutely right: businesses benefit from a strong higher education system. However, the primary beneficiary of higher education is the individual student. The student chooses where to study and what to study; and the student chooses where to use the new skills they have acquired. Businesses benefit from employing highly skilled graduates and they pay for that benefit through higher wages. Asking businesses to contribute through a new tax is also likely to mean that the higher education system will have to be more responsive to their demands; and there is a risk that these may displace the choices made by students. (HMG, 2010m: 54).

> we are committed to making the UK Government the most technology friendly in the world." (HMG, 2010b: 3). In his speech launching the blueprint, Prime Minister Cameron stated that: "The fact is that we are not as good as some of our competitors in turning great ideas on the drawing board into prototypes in a laboratory and actual goods and services people can buy. That's why I can announce today that we will invest over £200 million in Technology and Innovation Centres over the next four years. These centres will sit between universities and businesses, bringing the two together." (HMG, 2010d).

6.2.2 Measuring and Reporting on U-B Collaboration

Since 2005 the UK Government has issued annual reports of progress under its ten year science innovation investment framework and, in 2008, it also began issuing an annual *Innovation Report*. Both types of report reproduce data obtained from an annual "Higher Education - Business and Community Interaction Survey" conducted by the Higher Education Founding Councils. Table 17 (below) reproduces the results reported for the seven year period 2003-2004 through 2009-2010.

Table 17
Results from the UK Higher Education - Business and Community Interaction Survey 2003-2004 through 2009-2010

Percentage of UK HEIs that provide:	**2003-04**	**2004-05**	**2005-06**	**2006-07**	**2007-08**	**2008-09**	**2009-10**
Enquiry point for SMEs	n/a	89%	90%	91%	91%	93%	91%
Short bespoke courses on client's premises	n/a	78%	80%	84%	83%	88%	83%
Distance learning for businesses	n/a	66%	66%	68%	68%	68%	74%
Required contracting system for all consultancy	n/a	66%	68%	73%	75%	75%	71%
Income from all sources (£ millions)							
Collaborative research	0.614	0.587	0.645	0.703	0.713	0.732	n/a
Contract research	0.655	0.683	0.705	0.823	0.854	0.937	n/a
Consultancy contracts	0.239	0.248	0.262	0.303	0.343	0.332	n/a
Facilities and equipment related services	0.091	0.084	0.097	0.098	0.106	0.110	n/a
Continuing Professional Development Income	0.248	0.306	0.310	0.369	0.393	0.383	n/a
Intellectual Property income	0.043	0.063	0.063	0.068	0.068	0.124	n/a
Outputs from UK HEIs							
Patent Applications	1,308	1,648	1,536	1,913	1,898	2,097	n/a
Patents granted	463	711	577	647	590	653	n/a
Formal spin-offs established	167	148	187	226	219	191	n/a
Formal spin-offs still active after three years	688	661	746	844	923	982	n/a

<u>Source</u>: Higher Education Funding Council for England, Higher Education – Business and Community Interaction Survey. Cited in PraxisUnico (2010).

6.3 UK Governments as Enablers

6.3.1 Intermediary Organizations

The UK government provides support many intermediary organizations whose functions often include encouraging U-B collaboration. In the context of considerable fiscal pressure on the UK government for funding of higher education, the role of some of these institutions has come under criticism by the association representing UK universities (Universities UK). In August 2010, Universities UK released its *Future of Research* report to "help inform the government's spending and policy decisions which will impact significantly on the ability of the UK's universities to deliver the world-leading research which supports and drives the UK economy." The report states:

> "There are arguments for intermediate institutes, not carrying a full research mission, but set to effect the translation of research outcomes into applications and thus to support new products and processes. The Fraunhofer network (Germany) has recently been cited in the Hauser report as a model for 'Clerk Maxwell' institutions in the UK (as they were for 'Faraday' institutions by the Advisory Board for the Research Councils in 1992). The challenges for intermediate institutes are four-fold: as an island, they may be a haven for collaboration but require bridges to both universities and industry; they do not perform cutting-edge research; they are not a source of highly-trained people; and they lack the self-renewal of an institution that also teaches. They would require significant investment to have the capacity for significant outcome and this would in itself take time to build and emerge. While they can provide no rapid solution to current economic challenges, their investment would starve other targets of scarce resources. (Universities UK, 2010: 8).

As in previous sections of this report, examples of how UK governments have supported intermediary organizations are presented below in two categories: sectoral organizations; and horizontal organizations.

6.3.1.1 Sectoral Organizations

Technology and Innovation Centres (under the UK Technology Strategy Board)

The UK government and devolved administrations fund over 50 technology and innovation centres which take various forms and structures. Not all of these centres have U-B collaboration as their core function, but a number do. In January of 2010 the UK Government commissioned Dr. Hermann Hauser to review the current and future role of all the technology innovation centres. Hauser's final report, issued in March 2010, called on the government to provide sustained support for an elite group of centres "where there is genuine UK potential to gain competitive advantage." He criticized the existing governance and funding models for the existing centres and suggested that the UK's Technology Strategy Board should be charged with overseeing the new network of centres, "drawing on suitable representation from industry, the research base and wider

Government."(HMG, 2010q: 1). His first three recommendations were:

> 1. The UK Government should commit itself to establish, and provide sustained funding for a network of elite business-focused national TICs [Technology and Innovation Centres] in areas where the UK has the potential to gain substantial economic benefit
>
> 2. Government and the Technology Strategy Board should work with stakeholders across the private and public sector and publish a national strategy for the TICs including:
>
>   - setting a vision for their development over the next ten years. This should cover the role of TICs within the UK innovation system;
>
>   - criteria for establishing these elite TICs;
>
>   - the provision of public funding for them;
>
>   - achieving better co-ordination of the elite network of TICs, and
>
>   - their engagement with the wider science and innovation system in the UK and internationally.
>
> 3. When establishing new TICs, or enhancing and building upon existing TICs, decisions on their location must pay due consideration to their national nature, track record, the location of UK research excellence (in universities and elsewhere), alongside industrial capability and absorptive capacity." (HMG, 2010q: 24).

Dyson's March 2010 report to UK Conservative Party Leader (now UK Prime Minister) David Cameron, recommended a similar policy direction:

> "New university/industry research institutions capable of becoming centres of excellence in a particular research field should be given government sponsorship. These institutions should provide space for interactions, promote staff moving between business and academia and allow sharing of expensive resources. Government funding could be matched by industry, with any VAT issues resolved in advance. The key to success of these institutes is that industry will work in partnership with leading universities to identify priority areas for research and bring commercial expertise in developing emerging technologies from these institutes. In the current fiscal climate, this proposal would need to be considered alongside other spending capital and revenue commitments on research centres." (Dyson, 2010: 38).

The UK Government's July 2010 *A Strategy for Sustainable Growth* supported this policy direction (while linking it to possible unspecified reforms to the UK intellectual property framework). (HMG, 2010: 11). As previously mentioned, on October 25, 2010, UK Prime Minister David Cameron announced that the UK government would invest over £200 million in Technology and Innovation Centres over four years (2011-1015) and that would be overseen by the UK's Technology Strategy Board (TSB).[140] He stated:

> "These centres will sit between universities and businesses, bringing the two together. They won't just carry out their own in-house research, they will spread knowledge too, connecting businesses – large and small, new and old – to potential new technologies, making them aware of funding streams and providing access to skills and equipment. It's the sort of thing you see in Orgreave, where the University of Sheffield, Rolls Royce and Boeing are all working together or in Germany, where their Fraunhofer Institutes have been crucial in developing the MP3 licence. These centres will be great for research, great for business – and they're going to put Britain back at the top table for innovation." (HMG, 2010d).

On January 6, 2011, the TSB published an eight page *Prospectus* for the new centres, including an immediate invitation (replies requested by January 31, 2011) for organizations to register their interest in forming a technology and innovation centre focused on the area of high value manufacturing (HMG, 2011a). According to the *Prospectus*, three to four centres will be set up between 2011 and 2012, with up to five additional centres to be created after 2012. The *Prospectus* suggests that:

- **The centres will be "physical" institutions rather than "virtual networks."** They may be based at one location or "across a small number of sites, where there is a clear rationale for this in providing links to research capability or to customers." (The *Prospectus* contains no commitment to physically locating the centres at universities).

- **The centres will:**

  - provide businesses with access to world-leading technology and expertise;
  - reach into the knowledge base for world-leading science and engineering;
  - be able to undertake collaborative applied research projects with business;
  - be able to undertake contract research for business;
  - be strongly business-focused with highly professional delivery ethos;

[140] As discussed in section 6.3.1.2 of this report, the TSB was established by the UK Government in 2004 as a business-led advisory board. In 2007 the TSB was converted into an Executive Non-Departmental Public Body (i.e., it has executive powers but operates at arms-length from the UK Government). In operational form, it largely took over from the (former) UK Department for Innovation, Universities and Skills responsibility for the delivery of programs of energy and technology financial support.

- create a critical mass of activity between business and the knowledge base; and,

- provide skills development at all levels.

- **The first tranche of TICs will be in the areas of: high value manufacturing; energy and resource efficiency; transport systems; healthcare; ICT; and electronics, photonics and electrical systems.** The *Prospectus* does not explain why or how these five areas were chosen (although three of the six reflect TSB's own identified priorities for investment in technology application while the remaining three are aligned with the TSB's own priorities under its "innovation platforms" initiative. The prospectus does acknowledge that "this list represent very broad areas and we would expect the majority of centres to have a tight technical focus and definition."

- **The proposed TSB selection criteria for the centres are:**

  - the potential global markets which could be accessed through the centre are predicted to be worth billions of pounds per annum;

  - the UK has world-leading research capability;

  - UK business has the ability to exploit the technology and make use of increased investment to capture a significant share of the value chain and embed the activity in the UK;

  - technology and innovation centres can enable the UK to attract and anchor the knowledge intensive activities of globally mobile companies and secure sustainable wealth creation for the UK; and,

  - technology and innovation centres should be closely aligned with, and essential to achieve, national strategic priorities.

  The *Prospectus* suggests these criteria draw on the Hauser and Dyson reports and are "examples of international best practice." Perhaps not coincidentally, however, they are very much the same criteria (although not precisely identical) to the those applied by the TSB in making its own investment decisions (HMG, 2008a: 6).

- **The centres will gain their funds from "competitively earned" commercial funding and core TSB funding.** According to the *Prospectus*:

  > "The funding model will vary through the life of the technology and innovation centre and can be expressed in simplified terms as following the one-third, one-third, one-third model. Under this model centres would

> be required, when fully established, to generate their funding broadly equally from three sources:
>
> - business-funded R&D contracts, won competitively
>
> - collaborative applied R&D projects, funded jointly by the public and private sectors, also won competitively
>
> - core public funding for long-term investment in infrastructure, expertise and skills development.
>
> On the basis of international experience, we estimate core funding in the order of £5m to £10m per annum per centre, initially for five years, and renewable in similar increments. This is required to ensure centres are sustainable, to give business the confidence to invest and to enable them to leverage additional funding." (HMG, 2011a :5)

- **Governance arrangements will include:** an advisory oversight committee of all centres and reporting to the TSB's Governing Board; and an autonomous, business-led management board for each centre. The core funding agreement between each centre and the TSB will include an extensive list of accountability and reporting arrangements and well as an outline of principles for intellectual property management.

The *Prospectus* is not clear on how will success be measured. It states:

> "The ultimate measure of success for the new centres will be increased UK wealth creation from more effective commercialization of new technologies. But given the long timescale to deliver such benefits, and the practical difficulties in attributing them to specific sources, we will also need to develop intermediate measures. These will include the value of work won competitively such as number of new customers, successful projects, new and repeat customers/year, intellectual property developed and new businesses created. Environmental sustainability should underpin the requirement for all technology and innovation centres." (HMG, 2011a: 6).

Therapeutic Capabilities Clusters

In July 2009 the UK Government released its *Life Sciences Blueprint* that called for a new approach to collaboration in life sciences that would engage academic/NHS communities with the life sciences industry (HMG, 2009d: 6). In response, the UK Office of Life Sciences (within the Department of Business Innovation and Skills) and the UK National Institute for Health Research (NIHR) developed a Therapeutic Capability Cluster that was officially launched in October 2010 by the UK Minister of Business Innovation and Skill and the UK Minister of Health.

It is noteworthy - given this report's previous discussion of the different motivations and interests universities and industry bring to their collaborations with one another - how the program's designers have recognized that universities and industry likely have different interests in, and receive different benefits from, their participation in the new program (see text box below).

UK Therapeutic Capabilities Cluster Initiative

Benefits to academia / NHS researchers

- Access by academic researchers to industry lead compounds to conduct first-in-man studies with novel therapeutic agents, leading to the validation of new compounds and development and validation of new biomarkers.
- Sharing of expertise in methodology: joint development with industry of specialised protocols to address challenges (in inflammatory respiratory diseases and joint & related inflammatory diseases).
- Potential to undertake research jointly (academically and commercially driven) to investigate the utility of agents to treat inflammatory respiratory and joint & related inflammatory diseases in humans. …
- The research is likely to result in new discoveries and so lead to publications in high-profile journals targeting translational medicine…

Benefits to industry

- Faster development of drugs/interventions for companies with novel lead compounds.
- Improvement in the protocols used to evaluate new classes of medicines by refining approaches for measuring pathway function, identifying surrogates of disease and selecting appropriate patient populations with the leading therapeutic area scientists.
- Understanding of Proof of Concept, and Proof of Mechanism through studies with academic partners.
- An effective communication interface between therapeutic capability cluster and industry partners/collaborators through an ongoing programme of dialogue between capability cluster, industry and research funders.

Source: Extracted from UK National Institutes for Health Research. First Call for Proposals (March 2010).

6.3.1.2 Horizontal Organizations

UK Institute of Knowledge Transfer (IKT)

The IKT was launched in May 2007 with initial funding provided by the Higher Education Funding Council for England. The Institute's mission is to improve the skills and competencies of knowledge transfer practitioners; provide a structured career path for those working in the knowledge transfer field; and contribute to the professionalization of the field. [141]

The Institute is endorsed and supported (financially and otherwise) by a consortium of UK organizations in the field of knowledge and technology transfer, including the Intellectual Property Office, the UK Business Incubation Association (UKBI), the UK Science Park Association (UKSPA), Applied Industrial Research Trading Organizations (AIRTO) and National Health Service (NHS) Innovation Hubs; the higher education regional associations, the UK regional development agencies; and the funding and development agencies in Wales, Scotland and Northern Ireland. The Institute is open to all knowledge and technology transfer professionals (as individuals) from the higher education, public sector research establishments, and industry (including both large corporations and SMEs). (Hepworth-Sawyer, 2009)

National Council of Graduate Entrepreneurship (NCGE) and University Enterprise Networks

The UK Government launched the NCGE with funding of £ 700 thousand in 2003 and, at the time, Chancellor Gordon Brown set out the NGCE's role in the following terms:

> "The Council will act as a central information source for students and graduates. Its principal aim will be to engage career advisers, academics, institutions and organisations to raise the profile of entrepreneurship within universities and Higher Education Institutions. The Council will promote the idea of starting up in business as a viable career option with the objective of increasing the number of

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[141] Canada does not have a single organization that provides the same focus as the UK's IKT or that encompasses the broad range of interests and stakeholder support as does the IKT. Instead, there are a variety of different organizations with varying memberships which support professional development in the field of knowledge transfer. Examples include: the Canadian Federal Partners in Technology Transfer Organization (FPTT) which is oriented to technology transfer activities of the federal government; the Intellectual Property Institute of Canada (IPIC) which specializes in intellectual property rather than technology transfer activities more broadly defined; and the Canadian Association of University Research Administrators which supports a variety of professional development activities in knowledge transfer fields (CAURA is an associate member of AUCC (Association of Universities and Colleges of Canada) and fosters co-operation with sister organizations such as NCURA (National Council of University Research Administrators), SRA (Society of Research Administrators), AUTM (Association of University Technology Managers); CAUBO (Canadian Association of University Business Officers), CAREB (Canadian Association of Research Ethics Boards) and RAGnet (Research Administrators' Group Network)),

> students and graduates who give serious thought to starting their own business." (HMG, 2003: 60).

The aims of the NCGE have evolved and expanded over time. The NCGE's website (January 2011) states that the aims of the NCGE include such items as "long term cultural change in our universities" and "inform national and regional policies that affect enterprise and entrepreneurship in universities."

In addition, in 2008 the NCGE was selected by the UK Government to manage its University Enterprise Networks (UENs). The UK government launched the UEN as part of its UK Enterprise strategy (HMG, 2008b: 6) and with £ 3.5 million in funding. Each UEN network is comprised of university, business and UK regional development agency partners and jointly develop a four year plan that: "…focuses on building genuine business-university relationships tackling real issues relating to the businesses. The UEN plan also supports organisational change within the universities, embedding entrepreneurship across the institution and galvanises activity to engage the supply line of future graduates in the STEM subjects." (NCGE, Web).

According to a 2010 assessment of the UEN program conducted by EKOS (and commissioned by NCGE), there are 11 UENs at various stages of development across England and Wales with 49 founding partners: 17 Business; 23 Academic; and nine Government/public agencies (four UENs are operational). The EKOS assessment concludes that: "Although still at an early stage, the UENs offer strong potential to develop a genuinely new and cost effective approach to industry-academic collaboration, contributing to future innovation and enterprise performance. These are crucial areas for the UK as it moves from recession to economic recovery and growth." (EKOS, 2010: 3).

6.3.2 Other Enabling Measures

The UK government has put in place other enabling measures to encourage U-B collaboration, two of which are described in this section: the 2003 Knowledge Transfer Partnerships Program (which builds on an earlier Teaching Companies Scheme); and support for sector skills councils.

This section does not report on policies respecting the location and deployment of the UK Government's own research assets from a U-B collaboration perspective. However, it is an area worthy of further study. Two preliminary observations that would bear on this future research are:

- the UK government intramural R&D has undergone major institutional and funding changes over the past thirty years, including through a major privatization program of government laboratories in such areas as agriculture, transportation and defence (PREST, 2002). This may have reduced the necessity for, and number of, re-deployments of government research assets to support U-B collaboration objectives; and,

- the UK (through its research councils) has developed a “Large Research Facilities Roadmap” to guide public investment in, and the location of, large and publicly funded research facilities (the most recent version was issued in July 2010). While there is an extensive consultation process underlying this roadmap, it remains for further investigation the weight given to co-location with university and business facilities.[142]

Knowledge Transfer Partnerships

Between 1998 and 2003 the UK Government introduced 24 Faraday Partnerships to encourage closer contact and exchange between the science base and industry. The partnerships joined R&D organizations, universities, professional bodies, trade associations, and individual businesses and received core funding primarily from the UK research councils (£ 40 million). Starting in 2004, many of the Faraday Partnerships were folded into a broader program known as Knowledge Transfer Partnerships (KTP) program. The new partnerships were placed under the direction of the Technology Strategy Board (TSB -see section 6.4.2 below for a description of the TSB).[143] The objectives of the KTP today include:

- facilitating the transfer of knowledge and the spread of technical and business skills;

- providing company-based training for graduates in order to strengthen their business and specialist skills;

- stimulating and enhancing business relevant education and research undertaken by the knowledge base; and,

- increasing the extent of interactions by businesses with the knowledge base and their awareness of the contribution the knowledge base can make to business development and growth.

KTP is delivered through partnership agreements involving a company, an academic institution, and an academic supervisor. Almost 1,000 businesses and over 100 UK universities are involved in the program (as of December 2009). Engineering, management and computing departments together accounted for 71 percent of academic involvement in the partnerships.

[142] The UK Engineering and Physical Sciences Research Council plans to “…encourage operators of large scale research facilities to provide complementary services to industrial users (where there is a market), thereby securing leverage on public investment, the profit from which will be reinvested into service improvements for all users.” (HMG, 2010e: 10).

[143] The TSB initially relied on a third party agent, AEA Technologies, to deliver the KTP program but is now moving program delivery responsibilities in-house.

The TSB reports that, during the 2009/10 financial year almost £140 million was committed to the new KTP Partnerships in the form of grant support (which contributed £42 million) and business contributions (which provided £97 million). At the year end, the portfolio comprised 1,301 individual projects, comprising 1,102 “classic” KTP projects and 199 shorter KTP projects. (HMG, 2010a).

The KTP has been criticized for its small scale (Dyson, 2010: 30) even though the TSB’s 2008-2011 business plan calls for doubling the number of partnership and increasing their “flexibility”.

UK Sector Skills Councils

The UK has 25 Sector Skills Councils (SSCs) that represent the skills and training interests of employers. They are designed to build a skills system that is driven by employer demand. All SSCs are licensed by the Secretary of State for Innovation, Universities and Skills, in consultation with Ministers in Scotland, Wales, and Northern Ireland. Since 2004, the UK government (through the CES) has allocated approximately £ 40 million to the SSCs based on: the size and complexity of sector; past performance; and their capacity to generate external income. (HMG, 2008g: 5).

The SCCs predecessor organizations (the 76 National Training Organizations established by the UK government in 1998) largely focused on apprentice level training. In contrast, the SSCs have been encouraged to look at education at all levels from apprenticeships to graduate degrees (HMG, 2008c: 32). However, it does not appear that this policy direction will be strongly supported by the UK Coalition Government. The government’s November 2010 *Skills for Sustainable Growth Strategy* is almost entirely concerned with adult education and vocational training. The single substantive mention of universities is the statement: “We recognise that higher education (including higher education delivered through further education colleges), and post-graduate study, also play an important role in social mobility, and we will set out our strategy for higher education in a forthcoming white paper.” (HMG, 2010p: 10).

6.4 UK Governments as Funders

Examples of UK government policy instruments for encouraging U-B collaboration through funding are presented below under three headings: third-stream funding through the UK Higher Education Funding Councils (HEFCs); other research funding programs and organizations (e.g., the Technology Strategy Board, regional development agencies (now being replaced by new Local Enterprise Partnerships), and the research councils); and, other fiscal incentives (e.g., taxation of intellectual property and University Enterprise Funds).

6.4.1 Third-Stream Funding for Knowledge Exchange (KE)

The UK Government's most visible way of encouraging U-B collaboration is through what is known as third-stream funding. Third-stream refers to the third mission of universities to engage broadly with economy and society in addition to their education and research missions. It is delivered by the Higher Education Funding Councils to UK universities through a Higher Education Innovation Fund (HEIF). The UK government sets broad guidelines for third stream funding (over £ 1 billion between 2000/01 and 2010/11 measured at 2003 prices) while the universities decide on how it will be spent in light of their own priorities (HMG, 2003: 3). According to the Higher Education Funding Council for England:

> "Within the innovation system, third stream policy operates at the interface between the knowledge base, sources of new knowledge, networks and collaborative arrangements and firms' ability to absorb knowledge, technology and other expertise. It may be seen as an attempt to address institutional failure reflected in the inability of the innovation system to adapt to changed patterns of behaviour and rules or norms affecting interagent transactions which arise from broad underlying technological and other changes in the innovation system. (HMG, 2009a: 1-2).

Prior to 2005, funding was awarded through a competitive bidding process. In 2005 a new formula-based allocation process was introduced. The fourth round of HEIF funding (£ 400 million over the period 2008-2011) will be allocated entirely through a formula rather than a competitive process.[144] Over 50 percent (£ 207 million) of the round four funding will support knowledge exchange (KE) staff (HMG, 2008e: 18). A 2008 HEFCE evaluation report explained that:

> "Such [KE] staff play a variety of roles within the HEIs [Higher Education Institutions], typically relieving the administrative burden and other support-related burdens of KE engagement. For example, they provide capability to help write business plans and funding proposals and to advise on the costing and pricing of research proposals. They are also beginning to handle the contract negotiations between the different parties involved, an area that is becoming increasingly important and complex, ensuring that the HEI captures a fair value for the knowledge created. They play a very important co-ordination role, ensuring that KE engagements progress smoothly from inception to completion." (HMG, 2008e: 15-16).

The fact that half of third-stream funding goes to KE staff reflects in part the expansion in the number of UK university technology transfer offices over the 1990s. On this, point, Dyson (2010) states that: "Not all universities have sufficient research activity to justify a

[144] According to HEFCE (2008), the HEIF 4 formula is based on two components; the first focuses on capacity-building and potential for an HEI to engage, looking at the numbers of academic full time equivalent staff, while the second takes account of KE performance, based on various measures of income.

dedicated office. HEIF funding should focus on those offices with sufficient flow and a proven track record in knowledge transfer. Other universities should be encouraged to outsource or share resources with high performing offices" (Dyson, 2010: 37).

6.4.2 Other Research Funding Programs

The Technology Strategy Board (TSB)

The most recent UK government *Innovation Report* characterizes the TSB as " the prime channel through which the Government incentivises business-led technology innovation. It is a business focused organization with a leadership role to stimulate and accelerate technology development and innovation in the areas which offer the greatest potential for boosting UK growth and productivity." (HMG, 2011: 31).

The TSB was originally established in October 2004 as a business-led advisory board with a mandate to advise the Secretary of State for Trade and Industry on business research, technology and innovation priorities for the UK. In 2007 the UK Government converted the TSB into an Executive Non-Departmental Public Body (i.e., it has executive powers but operates at arms-length from the UK Government). In operational form, it largely took over from the (former) UK Department for Innovation, Universities and Skills responsibility for the delivery of programs of energy and technology financial support. Funding for the TSB was set at £711 million for 2008-2011.

Today the work of the TSB is overseen by a thirteen member Governing Board (although there are only 12 board members as of December 2010). Appointments to the board are made in accordance with the requirements of the Code of the Commissioner for Public Appointments (The TSB states that "All appointments are made on merit and political activity plays no part in the selection process." (TSB Web)). As of December 2010, 8 TSB board members had private sector affiliations and 2 had university affiliations. The two other board members are Jonathan Kestenbaum (Chief Executive of the UK's National Endowment for Science) and Iain Gray (CEO of the TSB). The Chairman of the Board is Dr. Graham Spittle, previously Vice President, World Wide Integration Development and Director of the IBM UK's Hursely Laboratories.

The UK Government is expanding the role and responsibilities of the TSB. For instance, in November 2010 the UK Government said that:

> "One of the problems technology companies face is the plethora of government policies, initiatives and bodies to navigate for advice. The Government has, therefore, taken action to streamline this cluttered landscape and make it easier for companies to get the support they need. This is why we are making the Technology Strategy Board a key channel through which we will incentivise business-led technology innovation in those sectors of the UK economy which present the greatest opportunity to boost UK growth." (HMG, 2010b: 9)

The UK Government has now given the TSB new responsibilities for R&D grant programs (currently operated by the UK's Regional Development Agencies) and has tasked the TSB with overseeing the creation, management and long-term funding for the new "elite network" of Technology and Innovation Centres (previously described in section 6.3.1.1 of this report).

Over the past six years, the TSB has focused its spending on priority technology and application areas and six innovation platforms that address "major policy and societal challenges." The TSB has various spending levers at its disposal and, while they are characterized by the TSB as "catalyzing and connecting" all innovation system players, in both design and implementation the focus of attention is the U-B relationship. Two examples are:

- **Technology Transfer Networks (TTN).** These networks are funded primarily by the TSB and aim to improve the UK's innovation performance by increasing the breadth and depth of knowledge exchange between companies and between business and academia in specific areas of technology. In 2008-2009, the TSB provided £ 19.8 million to support TTNs or almost 10 percent of the £ 199.5 million in TSB technology grants in that year (HMG, 2009: 34). As of early 2010 there were 24 TTNs (although, following a 2008 program review, the TSB anticipates this number will drop to 15 over the coming years).

- **Collaborative Research and Development Programme.** This competitive grant program, inherited in 2007 from the former UK Department of Trade and Industry, accounted for £ 114 million of the TSB's technology grants in 2008-2009, or 57 percent of total TSB technology grants in that year (HMG, 2009: 34). According to the TSB, the majority of the competitions are collaborative in nature and therefore projects must be delivered by a consortium. TSB program guidance is quite careful in its description of the role of academic institutions in proposed collaborations (see text box below).

TSB Collaborative Research and Development Program Frequently Asked Questions

Can an academic organisation apply?

In conjunction with at least one industrial partner, yes. However the project must demonstrate that it is industry driven and has industry commitment. There may also be some instances where the academic partner is treated the same (financially) as the industry partner (this will mean the funding limit to the academic is capped at a level lower than their usual 80 percent FEC [Full Economic Costs]… The academic, in such instances, will need to have alternative revenue streams to make up their contribution to the project.

Should the lead organisation in a consortium be an industry or an academic organisation?

The lead organisation, in most cases should be an industrial or commercial organisation, however, each competition has different requirements and rules... In all instances should an academic wish to lead a consortium the proposal must present a clear and full justification for this and the project must be industrially driven.

Can spinout companies from universities apply?

Yes. However, where the university or other public sector body has 50 percent or greater ownership of the spinout, the spinout will be treated as a large organisation, which will affect the eligibility of its costs and level of any grant that can be awarded…

Source: Technology Strategy Board, "Competition FAQs." TSB Website, accessed May 2010, at: http://www.innovateuk.org/competitions/competitonfaqs.ashx

UK Research Councils

In 2009 report the UK House of Common's Committee on Innovation, Universities, Science and Skills expressed surprise that the UK Research Councils are still sometimes seen as guardians of the independence of science. The Committee said:

> "Research Councils are not, and never have been, the 'guardians of the independence of science'. That responsibility has historically lain, and should remain, with the learned societies, universities and individual academics." (HMG, 2009e: 44).

Research Councils UK is the organization established in 2002 to represent the UK research councils (today there are seven UK research councils[145]). It describes its

[145] Research Council UK membership includes: the Arts and Humanities Research Council (AHRC); the Biotechnology and Biological Sciences Research Council (BBSRC); the Engineering and Physical Sciences Research Council (EPSRC); the Economic and Social Research Council (ESRC); the Medical Research Council (MRC); the Natural Environment

members' collaborative grant programs as being led by academic researchers, but involving contributions from partners. Research Councils UK's website (May 2010) states that its member councils collaborative research through a various mechanisms, including "responsive mode and schemes specifically aimed at encouraging academic collaboration with industry."

In 2006, Research Councils UK provided a series of recommendations to the UK Department of Business Innovation and Skills (BIS) for increasing the economic impact of Research Councils, including:

> "Research Councils should promote more extensive interchange of people and ideas between the research base, industry and public services. Research Councils should influence universities and Funding Councils to reward business interactions when allocating resources. In particular Research Councils should:
>
> - expand incentives for researchers to participate in knowledge transfer;
> - foster the development of partnerships between research groups in the UK and overseas centres of excellence;
> - encourage and reward two-way secondments between the research base and business;
> - encourage universities to make enterprise training widely available for researchers in all disciplines." (HMG, 2006c: 3)

One example of how the UK research councils are putting these recommendations into effect is found within the Engineering and Physical Sciences Research Council's 2011-2015 Delivery Plan. Notwithstanding that the Council's planned annual resource expenditures over each of the next four years represents a decrease in expenditures relative to 2010/2011, it remains committed to: "Encourage our key university, business and Government partners to align their strategies to a national agenda and priorities, and to create spaces for researchers and users to work together as normal business within that strategic framework." (HMG, 2010e: 4)

UK Regional Development Agencies (RDAs) and the new Local Enterprise Partnerships

The UK's RDAs, ten in all, were created in 1999-2000 and with a statutory mandate to encourage regional economic development. The UK Government has announced that the RDAs will be abolished by 2012 and be replaced by a system of Local Enterprise Partnerships (LEPs).

Research Council (NERC); and the Science and Technology Facilities Council (STFC).

The RDA's spent a total of £15.5 billion between 1999 and 2009 and, in 2009, had an annual budget of £2.3 billion (UK, 2009: xi). How much of this spending has been directly related to encouraging U-B collaboration is difficult to say. It is likely that RDA spending for "cluster development" and for "Science, R&D and Innovation Infrastructure" are the most germane spending categories.[146] The RDA's spent £ 364 million on cluster development between 1999 and 2009. (HMG, 2009c: 26-7).

The RDAs spent an additional £ 387.3 million on "Science, R&D and Innovation Infrastructure" between 1999 and 2009. How much of this spending might be attributed to encouraging U-B collaboration is not known. Much of the spending was on physical infrastructure, including broadband infrastructure. However, according to a PriceWaterhouseCoopers program evaluation, some portion was devoted to the development of university based science parks and "the encouragement of collaboration between higher education institutions (HEIs) and business, for example LDA's [London Development Agency] Jump Start programme to improve engagement between SMEs and Higher Education Institutions."[147] (HMG, 2009c 27).

The UK Coalition Government Agreement of May 2010 announced that:

> "We will support the creation of Local Enterprise Partnerships – joint local authority-business bodies brought forward by local authorities themselves to promote local economic development – to replace Regional Development Agencies (RDAs). These may take the form of the existing RDAs in areas where they are popular." (HMG, 2010p: 10)

In October 2010 the UK government released a White Paper, *Local Growth- realising every place's potential*. The paper states that the LEP will support high growth businesses, including:

> "…access to specialist strategic advice, coaching and mentoring to firms with high growth potential as they go through periods of rapid and dynamic change and bring a package of growth related services into one place around the firm. Growth hubs will act as a catalyst for growth by bringing together firms with high growth potential with finance and equity networks and other professional and knowledge services. Growth hubs will work closely with Technology and Innovation Centres as well as the majority of high growth potential firms who are not technology based. In order to target firms that have the greatest potential for growth, growth hubs will need to be delivered by specialist business support providers operating a highly distributed model that reaches across the areas covered by local enterprise partnerships" (HMG, 2010k: 42).

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[146] The RDA's spent an additional £ 387.3 million on "Science, R&D and Innovation Infrastructure" between 1999 and 2009.

[147] The London Development Agency's Jump Start program was a two year funding program launched in 2004 and that provided grants to SMEs to access various business services, including expertise within universities.

UK Innovation Vouchers for SMEs

The UK Government's 2008 white paper, *Innovation Nation*, announced the introduction of a voucher program for encouraging SME-university engagement. The vouchers allow eligible small or medium sized business to purchase an academic's expertise. In general, there are two levels of voucher available: up to £ 3,000 and up to £ 7,000 (although with regional variations). As of 2009, 1,300 innovation vouchers had been issued by the UK Regional Development Agencies, which exceeds the commitment in the *Innovation Nation* strategy to offer vouchers to 500 businesses (HMG, 2008f: 39). The UK Council for Industry and Higher Education (CIHE) reports that the UK voucher scheme is working well:

> "…significant evidence from [CIHE] workshops showed that [innovation vouchers] are effective in bridging the barriers companies have in engaging with universities. They also reduce the transaction costs which deter inexperienced companies in the formative stages of building links with universities. They may even lead companies to engage with the 'first' steps' on the escalator – taking on a graduate as a KTP associate, and perhaps even commissioning contract research from a university." (Ternouth et.al., 2010: 12).

The Higher Education Funding Councils (HEFCs) Research Funding and the Research Excellence Framework (REF)

The HEFCs provide UK universities with funding for university research (£1.76 billion in 2008). Up until 2009, this source of research funding was allocated partly on the basis of results from what is known as the Research Assessment Exercise (RAE). The RAE was a peer review process involving panels of academic experts. In September 2009 the HEFC for England published proposals for new arrangements known as the Research Excellence Framework (REF). These proposals included "research impact indicators" that would be used after 2014 to help inform funding decisions, including indicators for: creating new business; improving the performance of existing businesses, or commercialising new products or processes; and attracting R&D investment.

How the REF may unfold over the coming years is uncertain (a pilot project has been started). Dyson's March 2010 report to Conservative Party leader David Cameron was critical of the REF:

> "The proposed Research Excellence Framework (REF), which will form the basis for distribution of approximately £1.5 billion of research funding in 2009/10, introduces the notion of 'research impact' into the evaluation of research quality. The REF pilot requires academics to identify where they have built on research "to deliver demonstrable benefits to the economy, society, public policy, culture and quality of life". There is a risk that this becomes a fruitless, bureaucratic exercise which fails to recognize that the time lag between research and when it will make an impact can be impossible to predict. Even relatively 'applied'

> biomedical research, with a clear intended purpose, may find its application in an unexpected area." (Dyson, 2010: 35-36).

Dyson went on in his report to propose:

> "The current REF pilot is flawed and decisions should be delayed until lessons can be fully learnt from the pilots. As part of this learning process, a new government should examine whether an element of the assessment should focus on measuring and promoting networks with industry, other UK universities or not-for-profits. This would develop real incentives for academics to spend time in industry and identify useful research projects which could be jointly funded. In some areas, collaborations could be more limited (e.g. pure mathematics) and this will need to be factored into the overall assessment framework." (Dyson, 2010: 37).

Quality Related Research Funding Grants and the Institutional Costs of Research

Although the HEFCs are transitioning to allocating funding for university research through a new funding model (the REF), at the present time its largest research funding program is its Quality Related (QR) grant program (£ 1,097 million in 2009-10).

In 2007-08 the HEFCE created two different QR program elements: a Business Research Support Element; and a Charity Research Support Element.[148] For 2010-11, the Business Research Support Element will provide £ 64 million to 106 HEIs based on the amount of research income institutions receive from UK industry, commerce and public corporations (e.g., larger research-intensive universities receive more funding than those that are not).

A joint Research Councils UK and Universities UK report on the full economic costs of research states that QR-income <u>may</u> be used to contribute towards the full economic costs of commercially-funded research provided that there is an expectation of public good that justifies such use of public funds:

[148] The Charity Support Element amounted to £198 million in 2009-2010. As described by the AUCC: "Prior to 2006-07, part of the core QR block grant was determined on the basis of research funded by charitable organizations and businesses. Therefore, while the new separate allocation for charities provided £135 million in 2006-07, only about half that amount is new funding. This new commitment recognizes that charities are an integral part of the research landscape in English higher education and seeks to minimize the strain caused by research grants from the charitable organizations, which only cover a portion of the institutional costs to conduct the research. As the amount of research partially sponsored by charities grew over the last decade, universities struggled to cover the balance of the unfunded costs, particularly in the fields of medicine and science. The increased government support for charities research provided through HEFCE's QR funding has helped reduce the need for universities to draw on other university revenues to support that research."(AUCC, 2008a: 50-51).

> "Indeed there is an element in QR funding that relates to income from UK industry, commerce and public corporations; there is also an element related to income from eligible universities and overseas charities. The challenge for a HEI is to recover its full economic costs across its activities as a whole, thus pricing its research to maximise its income when there is the opportunity to do so, against the substantial non-financial benefits that accrue from engagement with research in collaboration with industry. It is also important to consider the non-financial elements that industry may bring to a collaboration which are not often even recognised by UK institutions; for example access to proprietary materials or new technologies that can help to drive the academic science." (HMG, 2010g: 25)

6.4.3 Other Fiscal Measures

The former University Challenge Seed Fund (1999) and the new University Enterprise Capital Fund

In 1999 the UK Government, through the HEFCs, launched a University Challenge Seed Fund to "assist the successful transformation of good research into good business" (HM Treasury, 2008). The UK government allocated £ 45 million to the first round of the competition for the seed fund in 1999 (with 15 seed funds being set up) and a further £15 million in 2001. Isis Innovation Ltd., a technology transfer company wholly owned by the University of Oxford, has succinctly described the purpose and objectives of the funds as follows:

> "The aim of the [University Challenge Seed Fund] Scheme was to fill a funding gap in the UK in the provision of finance for bringing university research discoveries to a point where their commercial usefulness can be demonstrated and the first steps taken to ensure their utility. The Scheme's primary focus was the exploitation of science and engineering research outcomes. HM Government has suggested that the availability of seed funds can help the commercialisation process in a number of general ways – financing access to managerial skills; by securing or enhancing intellectual property; by supporting additional R&D; construction of prototypes; preparation of business plan; covering legal costs; etc. The contributors to the Scheme were charities (Wellcome Trust and Gatsby Charitable Foundation) and HM Government. These central contributors committed a nationwide total of £40 million. These funds were divided into 15 University Challenge Seed Funds that were donated to individual universities or consortia. Each recipient university of a University Challenge Seed Fund had to provide 25% of the total fund from its own resources." (Isis Innovation, 2010 Web).

In March 2010 the UK Government announced that a new University Enterprise Capital Fund will be established to provide early stage funding for the commercialization of promising university inventions and innovations. As originally envisioned, the £ 37.5 million fund (with a government contribution of £ 25 million) will: "Support universities seeking to commercialise their Intellectual Property, particularly patented inventions."

(HMG, 2010c). In June 2010 the UK Government suspended the creation of the fund pending completion of its comprehensive spending review. Following publication of the review, David Willetts (Minister of State (Universities and Science), Business, Innovation and Skills, tabled the following written response to a Parliamentary question on the status of the initiative:

> "The Government are [sic] committed to the continuance of the Enterprise Capital Fund programme that supports investments for the highest growth potential small businesses in the 'equity gap'. The spending review settlement will allow us to commit a further £200 million to new Enterprise Capital Funds over the coming four years. The Government's expert small business investment arm, Capital for Enterprise Ltd, have a pipeline of potential new Enterprise Capital Funds with whom they are in discussion and they anticipate the first of these to be investing early in the new year. There are a number of potential university focussed propositions among that pipeline which will be considered as they come to fruition." (HMG, 2010s: Column 875W).

Taxation of Intellectual Property

Under a Patent Box tax regime (sometimes known as a Royalty Box), revenues from certain areas of IP, such as pharmaceutical patents, are taxed at a lower rate. The UK Government's March 2010 Budget provided that the rate of corporation taxation applied to income from patents will be reduced starting in April 2013 in order to "strengthen incentives to invest in innovative industries."

This measure, whose introduction was confirmed in the UK Government's June 2010 budget, is widely regarded as bringing the UK fiscal regime for patent income in line with some other EU jurisdictions, but also as providing an incentive for U-B collaboration on the commercialization of intellectual property. The Chairman of PraxisUnico, Professor David Secher, responded to the new initiative by stating:

> "The [2010] Budget recognises the UK's world-class research base and promises measures to "to support universities and encourage innovation [and] to facilitate the commercialisation of research and intellectual property." One such measure is the new "Patent Box", a reduced rate of Corporation Tax on income from patents from 2013. Clearly there is a huge amount of work to be done in defining the details (and as always "the devil is in the detail"), but this is potentially an important measure in attracting and retaining industries based on university intellectual property (IP), including spin-out companies." (Secher, 2010).[149]

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[149] Praxis was originally set up through the U.K.'s Cambridge/MIT Institute in 2002 to develop and run technology transfer courses in the UK. UNICO was established in 1994 by UK university managers to coordinate technology exploitation within Technology Transfer Offices. In July 2009 the two organizations agreed to merge and to form a single educational not-for-profit organization. See: http://www.praxisunico.org.uk/

The UK Government is now considering how fiscal incentives can prevent "offshoring" of IP, and which if implemented, will have far broader impacts than just on U-B collaboration but will likely affect U-B collaboration. In November of 2010, the UK Treasury issued a consultation paper on corporate taxation of IP (and also possible reforms to the UK's R&D tax credit system). The consultation paper states:

> "The Government also recognises that IP is mobile and that multinational groups have a choice as to where to locate their IP ownership. IP ownership is distinct from the R&D, management, and manufacturing activity necessary to develop and exploit it, but there are clear commercial links and IP ownership is frequently co-located with high value jobs and economic activity.
>
> The Government recognises that some patent-rich UK businesses face a higher overall effective tax rate than their foreign competitors, who may benefit from special regimes available in other countries. While the Government does not feel that it is necessary to match these regimes, it does recognise that there is a need to improve the competitiveness of the UK corporate tax regime to complement the non-tax advantages of the UK as a leading location for R&D and IP.
>
> …The Patent Box will aim to reward successful technical innovation. The Government believes that it is right to introduce this reform now in order to prevent movement of IP offshore and encourage the development of new patents by UK businesses, protecting and enhancing the status of the UK as a world leader in this field." (HMG, 2010*l*: 51).

6.5 UK Governments as Rule-makers

Two examples of UK governments as rule-maker for U-B collaboration are in the areas of intellectual property and, where the UK government exerts indirect influence, university governance.

6.5.1 Intellectual Property (IP)

The UK Government states in its 2010 *Blueprint for Technology* strategy that:

> "In a knowledge-intensive economy like ours the intellectual property framework – the rules and practices that let businesses own and protect their ideas – is crucial. We need to make sure that we can grow the dynamic businesses of tomorrow, not just support the big businesses of today. In particular, we need to ensure that the UK intellectual property framework maximises support for technology innovation and creativity." (HMG, 2010b : 6)

The UK Government subsequently announced that Professor Ian Hargreaves of the Cardiff Business School will lead an independent review into how the IP system can better drive growth and innovation. It remains to be seen whether the review, scheduled to be completed by April 2011, will include consideration of IP issues relating to U-B collaboration. The review's terms of reference appear to focus more on digital copyright issues and states that:

> "It [the review] will examine the available evidence as to how far the IP framework currently promotes these objectives [growth and innovation], drawing on US and European as well as UK experience, and focusing in particular on:
>
> - Identification of barriers to growth in the IP system, and how to overcome them;
>
> - How the IP framework could better enable new business models appropriate to the digital age. (HMG, 2010i 1)

In the past, IP issues within the context of U-B collaboration have been of considerable concern and attention for UK governments. For example, The 2003 Lambert review of business-university collaboration expressed concern that the lack of clarity over the ownership of IP in research collaborations was making negotiations longer and more expensive than otherwise would be the case. But the review argued that the UK should not introduce legislation giving IP ownership to universities along the lines of the US *Bayh-Dole Act*:

> "Bayh-Dole was introduced in a very different environment to that of business-university relationships in the UK, where universities have controlled IP from publicly-funded research since 1985. According to companies already involved in research collaborations with British universities, introducing similar legislation in the UK today would present greater risks to existing collaborations than it would bring benefits by improving clarity in negotiations for new projects" (HMG, 2003a : 4).

This view is consistent with the review's belief that: "universities may be setting too high a price on their IP."

The Lambert Review recommended adoption of a "common starting point" for negotiations between universities and industry through development of a "common IP protocol." (HMG, 2003a: 122-123). In May 2004 the UK Government established the Lambert Working Group on Intellectual Property whose functions included the development of model IP agreements. Members of the working group include: the Association of University Research & Industry Links (AURIL), the Confederation of British Industry, UK Regional Development Agencies, PraxisUnico, several UK companies and universities and representatives from several UK government departments. The UK government's Intellectual Property Office (IPO) provides the secretariat for the working group. According to the IPO:

> "The aim of the model agreements is to maximise innovation. They have not been developed with the aim of maximising the commercial return to the universities; but to encourage university and industry collaboration and the sharing of

> knowledge. They do not represent an ideal position for any party; depending on the circumstances they are designed to represent a workable and reasonable compromise for both or all parties." (IPO, 2010, Web.)

The UK government's 2006 review of intellectual property (Gower) asserted that the model agreements (and other supporting tools) were working well: "Since the introduction of the model agreements, the level and quality of business university collaboration has improved." (HMG, 2006a: 90). To substantiate this assertion, the Gower Review cites the 2002-2003 Higher Education Business and Community Survey published in 2005 by the Higher Education Funding Councils. However, that particular survey, while concluding that there was a continuing improvement in HE-business interactions, contains no analysis and draws no conclusions with respect to the influence of the Lambert model IP agreements.

6.5.2 University Governance

How universities are governed matters for many reasons, the most of important of which – in western universities – is its relationship to the core value of academic freedom and ideas of university autonomy. In 2009, the European University Association (EUA - the representative organization universities and national rectors' conferences in 46 European countries and which has 77 UK university member institutions) issued the *Prague Declaration*. The Declaration states that strong and flexible universities pursuing excellence in their different missions requires (among other items):

> Shaping, reinforcing, and implementing autonomy: universities need strengthened autonomy to better serve society and specifically to ensure favourable regulatory frameworks which allow university leaders to; design internal structures efficiently, select and train staff, shape academic programmes and use financial resources, all of these in line with their specific institutional missions and profiles. (European University Association, 2009).

In the UK, and perhaps largely in recognition of concerns over university autonomy across its various dimensions, governments have been cautious in their interventions even as they consider that how universities are governed and managed is an important aspect of U-B collaboration.

The 2003 Lambert Review found that UK business was critical of what it sees as the slow-moving, bureaucratic and risk-adverse style of university management. Although the review found that there have been marked changes for the better over the past decade in the way that universities are run, it also stated:

> "…while the direction of reform in the sector is right, the pace varies widely. The next decade will present new challenges, as institutions compete on a much wider stage and as they continue to expand their third stream activities. So there needs to be a renewed effort to ensure that both management and governance are fit for modern times."(HMG, 2003a: 93).

The Lambert Review recommended that:

- a voluntary code of governance should be developed, to represent best practice across the university sector;

- each university governing body should systematically review its effectiveness in carrying out its obligations to all stakeholders every two or three years; and,

- a Leadership Foundation initiative should be supported to address the university sector's need for high-quality leadership and senior management.

The UK Government's response to these recommendations, set out in an annex to the UK Treasury's 2004-2014 Science and Innovation Investment Framework, was crafted to suggest that the government would support actions already being taken by UK universities on their own initiative:

> "The Government welcomes the work the Committee of University Chairmen is undertaking to revise its guidance on good governance and to develop a code to be published in autumn 2004. …The Government fully supports a code that challenges the sector to meet best practice. The Government also recognises, however, that good practice exists in structures or processes outside that of the proposed code. The code should not become a national prescription. Where an institution's practices are not consistent with particular provisions of the code, an explanatory note should be published in the corporate governance section of the audited financial statements. …The Government would recommend that the code be revised regularly by the sector to ensure it remains at the forefront of best practice." (HMG, 2004a: 177).

It remains to be seen what policy directions the UK government will take on university governance and management issues (or if they will see it as an important area for its attention at all). At the sub-national level, some devolved administrations are not waiting for UK government direction. In July 2010 the Welsh Assembly issued its *Economic Renewal* statement in which it said:

> "Higher Education in Wales makes a major contribution to the economy. The sector develops the advanced skills required by the most innovative businesses, creates and transfers knowledge, and is a significant employer and purchaser of goods and services in its own right. While there is already evidence of a strong multiplier effect from existing public investment in Higher Education we believe that there is more and further benefit to be gained in the future. We will complete our review of Higher Education governance to ensure that governing bodies are appropriately structured to drive change and, if need be, challenge institutional management." (HMG, Welsh Assembly Government, 2010f: 26-27)

6.6 Summary Findings

During the post-1945 period through to the early 1990s, UK governments did not consider U-B collaboration as an economic or education policy concern or priority. There are a number of possible explanations for this, some of which are rooted in the UK's post-war recovery economic experience but others in the structure and culture of its university system.

Since the 1990s, there has been a fundamental change in UK circumstances and attitudes on the importance of U-B research collaboration and the role of UK governments in encouraging U-B collaboration. No other OECD government has been a louder advocate for U-B collaboration than has the UK Government. There is no indication that this advocacy role has diminished with the election of the new Coalition Government in May of 2010.

The UK Government, as well as UK businesses and universities, have had a clear plan to guide U-B collaboration with the publication of the 2003 Lambert Review of Business and University. However, as the impact of the plan represented by the Lambert Review aged and was overtaken by events, there emerged in the UK a growing sense that "more can be done." The Hauser report (2010) is, in some senses, a new compass while the UK Government's November 2010 *Technology Blueprint* is a new roadmap – one that merges U-B collaboration more closely than ever with innovation policy goals. In his report to the UK government, Hauser envisioned an elite network of "translational infrastructure" centres drawing on models found within such other countries as: Germany (the Fraunhofer Gesellschaft); Taiwan (the Industrial Technology Research Institute); South Korea (the Electronics and Telecommunications Research Institute); and the Netherlands the TNO organization). It remains to be seen how easily foreign models can be tailored to the particular challenges and circumstances found within the UK and what results will emerge from the new £ 200 million investment in Technology and Innovation Centres.

Among the many spending measures UK governments have taken over the past twenty years to encourage U-B collaboration, none has been so visible or as expensive as "third-stream" funding for knowledge exchange activities by universities. Much of the over £ 1 billion pounds in funding over the past ten years has gone to support knowledge transfer personnel within universities (possibly up to 50 percent of this funding). As reported in the first section of this report, the UK may now have more university based research commercialization staff per unit of university research expenditure than in Canada, the US and Australia – although this statistic is subject to further research and confirmation. As also reported in the first section, the UK has climbed (although not steadily) up the rankings of the World Economic Forum's Executive Opinion Survey results on U-B research collaboration: from 14th place in 2001 to 4th place today. Whether this result is attributable to third-stream funding is, however, unclear.

As rule-maker for U-B collaboration, the UK Government's approach to university governance may largely be characterized as informal rather than direct and highly coercive. UK university governance systems (broadly defined) have been identified by major influencers (i.e. Lambert and Sainsbury) as a significant barrier to university-industry collaboration. Reforming university governance has been a continuing UK government policy pre-occupation. With respect to intellectual property, large investments of time and other resources have been placed on the development of "model agreements" by UK Lambert Working Group. Beyond seeking to introduce greater certainty and clarity with respect to IP negotiation processes, UK governments are also using fiscal incentives to capture benefits from the commercialization of IP (whether originating or owned by universities or others).

7.0 Australia

7.1 Context

Australia has 37 public and 2 private universities. Total enrollment in Australia's tertiary education sector (which includes 150 specialized, mainly private, educational institutions) was 1.1 million persons in 2008. Under the Australian constitution, State and Territorial governments are responsible for higher education and Australian universities are generally established through State and Territory legislation. Australian universities have received most of their public funding from the Australian Commonwealth Government since the 1940s.

The main association representing Australian universities was re-branded as Universities Australia in 2007 (its origins date back to the 1920s and the formation of the Australian Vice-Chancellors' Committee (AVCC)). The main business-university forum is the Business-Higher Education Round Table (B-HERT), a not-for-profit organization established in 1990. Membership of B-HERT comprises Australian universities, corporations, professional associations, and the major public research organizations, including the Commonwealth Scientific and Industrial Research Organization (CSIRO).

There are three potential reasons why, after the Second World War and through to the 1980s, Australian federal governments did not view encouraging U-B collaboration as a significant policy priority or concern.

First, during much of the post-war period, Australia's manufacturing sector was protected by a high tariff wall, relied upon imported technology, conducted very little R&D itself, and largely served a small domestic market. These circumstances were unlikely to have created great incentive for the manufacturing sector to seek access to knowledge found in universities and, in turn, may help explain the absence of significant government policy interest in U-B collaboration.[150] Only in the 1980s did manufacturing R&D expenditures climb rapidly (see Figure 11 next page).

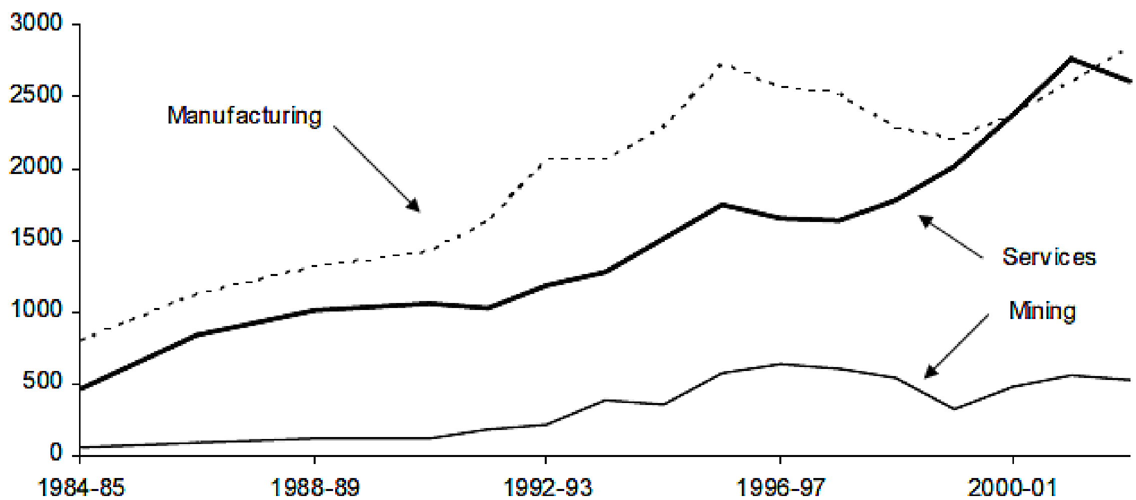
To the extent that U-B collaboration was prominent before the 1980s, and was supported by Australian federal, state and territorial governments, it generally involved the two economic sectors most exposed to international competition and most reliant on international markets: mining and agriculture. The Australian Mineral Industrial Research Association (AMIRA) Association was founded in the 1950s to foster co-operative research between the industry, universities and the Commonwealth Scientific and Industrial Research Organization (CSIRO).[151] The Australian Mineral Foundation (AMF)

[150] This is not to say that the Australian federal government did not support and promote R&D in the manufacturing and other sectors during the post-war period, first through the Secondary Industries Commission and then later through its successor organizations.

[151] Australian universities and colleges had a long history of working closely with the mining and mineral industries dating back to the late 19th century.

was established in 1972 and included the majority of Australian exploration, mining and petroleum companies, all Australian federal and state geological surveys and the majority of universities.[152] In the agricultural sector, the Rural Research and Development Corporations (RDCs - established on a statutory basis in 1989 but which found their origins in the 1930s) grew in number through the post-war period and with government support. Voluntary levies on wool commodities co-funded with matching government grants to fund research were first introduced in 1936. Mandatory levies on a wider range of commodities were introduced in the 1950s (Alston et. al., 1999).

Figure 11
Australian Business R&D Expenditures 1984-85 to 2002-2003 (Millions of A$)



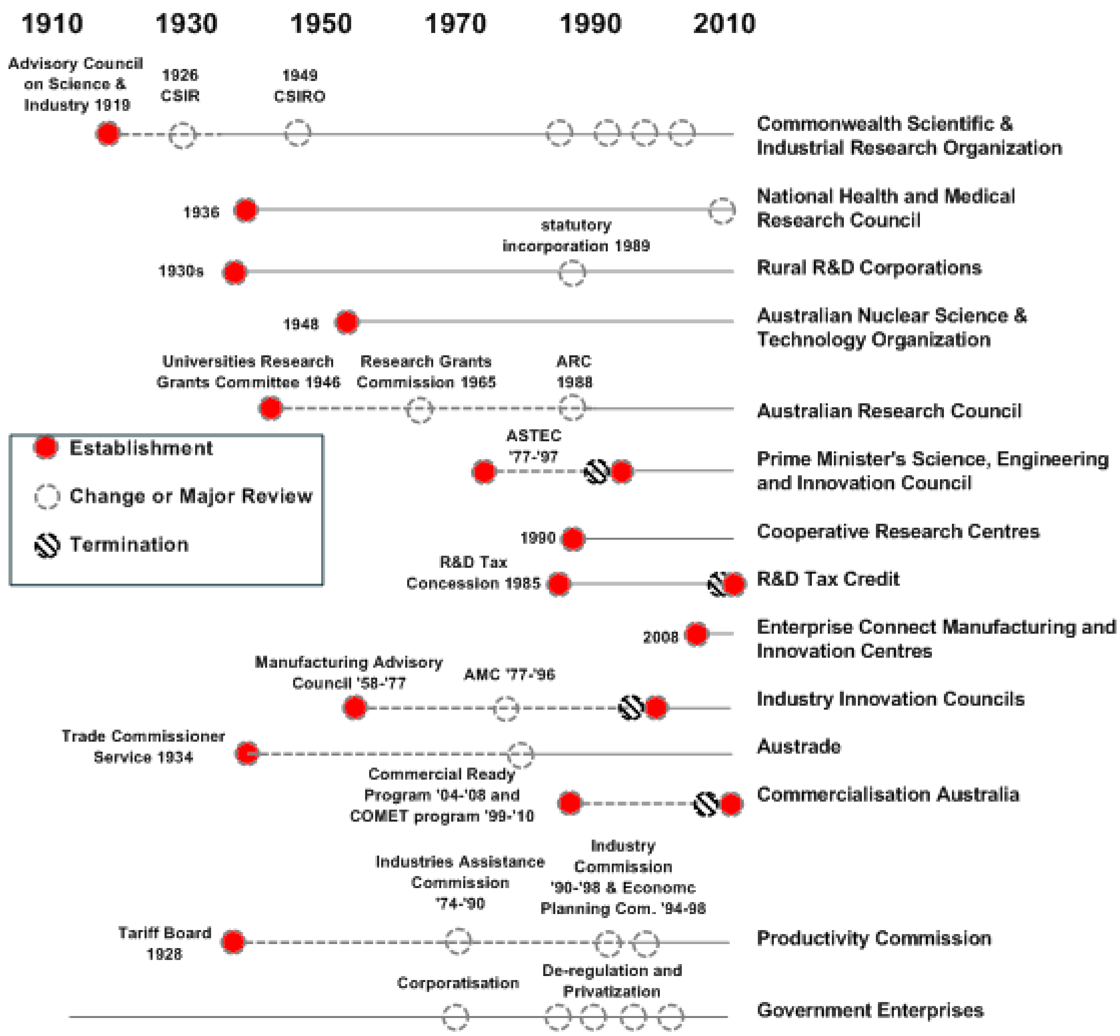
Source: Sid Shanks and Simon Zheng (2006)

Note: Shanks and Zheng explain that Business R&D expenditure surged between the mid-1980s and mid-1990s as the R&D tax concession lifted expenditure and competitive pressures increased, especially in the manufacturing sector due to the rise of Asian competition and to reductions in trade barriers. Business R&D expenditure switched more heavily into services areas in the 1990s.

A second possible reason for federal government disinterest in U-B collaboration through to the 1980s is that growth in the government science base may have "crowded out" private sector interest in collaborating with universities. Figure 12 (next page) summarizes Australia's evolving institutional architecture for innovation at the federal level.

[152] The Australian Mineral Foundation operated until 2001, although some of its key functions have continued on through other organizations.

Figure 12
The Evolution of Australian Federal Institutional Architecture for Innovation (illustrative not comprehensive)



Source: Cutler and Company (2008). Reproduced with permission.

Note: Presentational adjustments and updates made to the source diagram by the author.

A third possible explanation for the lack of government attention to U-B collaboration may be Australia's "binary-like" structure for higher education (and funding) that emerged during the post war period and existed through to the 1980s. Binary systems have demarcation in structure and funding between universities and vocational or near-vocational educational institutions. A binary-like system of higher education had developed in Australia over time and was given greater definition with the implementation of recommendations from the 1964 *Report of the Committee on the Future of Higher Education in Australia* (Martin), including the creation in the late 1960s of Colleges of Advanced Education (CAEs). CAE's sat between the universities and the trades-oriented Colleges of Technical and Further Education (TAFE). Perhaps binary education systems serve to reduce the demand for governments to align "higher education missions" with "industry needs", although this is just a hypothesis requiring further research to support, dismiss or qualify.

The interest of the federal government in encouraging U-B collaboration visibly increased during the 1980s. One signpost and driver of change was the federal government's series of reforms in the higher education sector (which came to be known as the "Dawkins' Revolution" after the Minister of Education of the day, John Dawkins). The reforms involved a number of elements, including:

- promotion of institutional mergers, particularly the merger of CAEs with universities;

- re-introduction of student fees through the Higher Education Contribution Scheme – later replaced by the Higher Education Loan Program. (Student fees had been abolished in 1973);[153]

- replacement of the single funding body, the Commonwealth Tertiary Education Commission (CTEC), with four specialist councils, including a National Board of Employment, Education and Training and, with respect to research funding, the Australian Research Council.

The impact of the structural reforms was immediate and highly visible. In 1987, Australia's higher education sector consisted of 19 universities (183,100 students) and 46 CAEs and eight other institutions (204,700 students). By 1991, there were 31 universities with a total student enrolment of 534,600 (Gamage, 1993). A desire to change the relationship between universities and industry was not the only policy reason behind the Dawkins' reforms, but it was one reason (Penington, 1991).

The structural changes to Australia's higher education system occurred concurrently with: a renewed concern with Australian productivity performance in the late 1970s; the opening up of the Australian economy during the 1980s and 1990s through:

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[153] As reported by Karmel (1999): "The composition of funding has been far from static. Major structural changes occurred in the second world war when the States lost their powers to collect income tax, in the 1950s when the Commonwealth Government assisted States with matching grants to universities, in the 1960s with the growth in colleges of advanced education (polytechnics and teacher colleges), in the 1970s when the Commonwealth took over from the States full funding responsibility and abolished fees and in the late 1980s when HECS [Higher Education Contribution Scheme – later replaced by the Higher Education Loan Program] was introduced." However, it remains for further research what impact public funding structures for higher education may (or may not) have on U-B collaboration. Does a shift to greater private financing (via tuition fees) create an incentive for universities not only to be more active in attracting students, but also tying their education curricula and course offerings more closely to current and projected labour market demands?

implementation of two rounds of micro and macro economic reforms; and adjustment to significant global economic and technological change. It is within this changing education, economic, and technological environment that Australian federal, state and territorial governments have been deepening their engagement as advocates, enablers, funders and rule-makers for U-B collaboration.

7.2 Australian Governments as Advocates

7.2.1 Statements and Strategies

Australian federal government innovation and education policy and strategy documents over the past decade have each contained strong references to a need to strengthen U-B collaboration. Examples include:

- **White Paper on Knowledge and Innovation (1999).** This policy statement from the Department of Education, Science and Training (DEST) set out a new research funding framework for universities and announced that the Australian Research Council (ARC) would become an independent funding body. It also said that university-industry collaboration is a "principle for the funding of higher education research and research training" and that:

  > "The policy framework should encourage and reward the development of an appropriately entrepreneurial culture in which researchers and the various institutions collaborate among themselves, across the world and with other players in the innovation system. Collaboration should encompass the sharing of knowledge, technique, expertise and research infrastructure and take varying forms, including cooperative projects and student and staff exchanges. Universities should have policies and structures in place to facilitate the commercialisation of discoveries, with particular regard to regional spin offs."(CGOA, 1999: 7).

- **Backing Australia's Ability (BAA - 2001).** This innovation strategy set out a federal government investment plan of A$ 2.9 billion over five years (this was in addition to initial investments announced in the federal government's 1997's *Investing For Growth* strategy). BAA states that: "Backing Australia's Ability assists the greater commercial application of research from universities and public sector research agencies, like the CSIRO [Commonwealth Scientific and Industrial Research Organization], by strengthening the commercial linkages with industry and making it easier to take promising research to the stage of commercial viability." (CGOA, 2001:18) One of the BAA's major funding initiatives was an A$ 227 million expansion over five years of the Co-operative Research Centres (CRC) program.

- **Our Universities: Backing Australia's Future (2003).** This federal policy statement announced reforms in: block grant funding; performance-funding of teaching; workplace productivity; governance; student financing; and cross sectoral collaboration and quality. The A$ 1.3 billion reform program included a new A$ 36.6 million Collaboration and Structural Reform Fund. A Business, Industry Higher Education Collaboration Council (BIHECC) was created in 2004, one of whose functions was to advise on the allocation of monies from the fund.

- **Backing Australia's Ability - Building our Future through Science and Innovation (2004).** This federal policy statement provided details on a further A$ 5.3 billion (over five years) in federal government funding for innovation and research programs. The document said:

> "A fundamental objective of this package is to boost collaboration between the key players in the innovation system: business, universities and publicly funded research agencies. Collaboration increases the 'interconnectedness' of the system, providing more and varied pathways for research to be used and commercialised." (CGOA, 2004: 7).

- **Australian Productivity Commission (APC) report on Public Support for Science and Innovation (2007).** In March of 2006, the federal government requested the APC to conduct a study of public support for science and innovation. One of the four areas the Commission was asked to examine was collaboration between research organisations and industry. The APC's findings included: "While there is scope for universities to improve their linkages with firms and the wider community, this does not require a new dedicated funding stream for universities"; and "new intermediary arrangements aimed at better diffusion of complex knowledge from universities to businesses are being trialed and will provide a useful experiment." (COGA, 2007b: vii).

- **Venturous Australia (2008).** This report to the Minister for Innovation, Industry, Science and Research on Australia's innovation system found that:

> "Facilitating collaboration among key Players – especially firms, research institutions and universities. Collaboration is critical for our relatively small national innovation system. Through collaboration we build skills, we concentrate and focus action and it also assists both building the absorptive capacity of firms and research providers as well as increasing the opportunity for further attraction of investment into Australia. After all, firms and research providers, whether in Australia or overseas, are the key players in the innovation system." (CGOA, 2008g: 116-117).

- **Review of Australian Higher Education (2008).** In March of 2008 the federal government asked Dr. Denise Bradley to chair a review panel on the higher education sector. The review panel's final report contained 46 recommendations including: setting national targets for degree attainment; increasing federal-subsidized places for qualified students; strengthening accreditation processes for universities; and establishing a national accountability framework.
  The Bradley Review generally deferred to the findings of the Cutler report and the

(then) forthcoming federal innovation strategy when it came to consider the position of the higher education sector within Australia's innovation system. However, the Review did oppose the introduction of third stream funding for university engagement with business and other external organizations:

> "Engaged teaching and research should be the norm in universities. However, institutional resources to support engagement have been placed under pressure as a result of the reductions in the real level of public funding per student for teaching and related purposes, and the failure to provide full funding for the costs of Commonwealth sponsored research. …The panel concluded that, given the integral nature of this engagement, a separate stream of funding is not desirable. Hence, provided that the Commonwealth contribution for teaching and research block grants is increased as proposed above and that appropriate indexation is applied, there should not be separate 'third stream' funding for knowledge transfer or engagement." (CGOA, 2008f: 169).

The Bradley report also rejected any suggestion that university-industry collaboration should support a central labour force planning model:

> "Higher education's collaboration activities with industry and business were described in many submissions as largely ad hoc arrangements. While there was considerable support for a more coordinated national approach to encourage business and industry engagement, submissions did not generally support a central labour force planning model for the allocation of higher education funding."(CGOA, 2008f: 210).

- **Powering Ideas - An Innovation Agenda for the 21st Century (May 2009).** The strategy document was released with the federal government's May 2009 budget. It identifies seven innovation priority areas for Australia, including:

> "Priority 5: The innovation system encourages a culture of collaboration within the research sector and between researchers and industry. Target: The Australian Government's ambition is to double the level of collaboration between Australian businesses, universities and publicly-funded research agencies over the next the next decade.
>
> Priority 6: Australian researchers and businesses are involved in more international collaborations on research and development. Target: The Australian Government has adopted the long-term aim of increasing international collaboration in research by Australian universities." (CGOA, 2009i: 4).

The strategy states that in some cases encouraging a culture of collaboration "may just mean persuading people to talk to each other" but also that: "In other cases, it will be necessary to establish more formal partnerships, resource-pooling arrangements, exchanges of personnel, and lines of communication." (CGOA, 2009i: 59).

- **Transforming Australia's Higher Education System (July 2009).** The initiatives outlined in this federal government policy statement from the Department of Education, Employment and Workplace Relations are presented as a "quantum leap in resourcing" designed to: "support high quality teaching and learning, improve access and outcomes for students from low socio economic backgrounds, build new links between universities and disadvantaged schools, reward institutions for meeting agreed quality and equity outcomes, improve resourcing for research and invest in world class tertiary education infrastructure." (CGOA, 2009*l*: 5) The statement also announced the introduction of a new Joint Research Engagement program to give greater emphasis to end-user research by encouraging and supporting collaborative research activities between universities, industries and end users.

Most recently, in October 2010, the Australian Industry Group (a national industry association created through the merger of the Australian Metals Trades Association and the Australian Chamber of Manufacturers in 1998) published a report on innovation by its Innovation Steering Group, *Innovation: New Thinking New Directions*. The 10 member steering group, in addition to private sector representatives, included representatives from the University of Queensland's business school and from the State Government of Queensland's Department of Employment, Economic Development and Innovation. The report highlights Australia's low ranking in the OECD Scoreboard results on U-B collaboration and recommends that:

- the Government and the Australian Research Council widen the definition of impact to include industry engagement on commercial terms;

- industry, universities and Government develop appropriate metrics for the measurement of effective industry engagement;

- a knowledge base of effective collaboration models covering diverse IP and industry requirements be developed; and,

- successful collaboration initiatives from Australia and internationally are showcased (Australian Industry Group, 2010: 14).

7.2.2 Measuring and Reporting on U-B Collaboration

The role of the Australian federal government as an advocate of U-B collaboration is also apparent in what it is Australia's innovation system performance.[154] The federal

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[154] During the 2010 Australian federal election campaign, both the Coalition Party and the Labor Party endorsed the need for an evidence-based Australian national science communications strategy such as set out in 2009 report to the federal Department of Innovation, Industry, Science

government's 2009 *Powering Ideas* innovation agenda included a commitment to produce an annual report on the performance of the national innovation system and the first such report was issued in April 2010. Table 18 (next page) reproduces the table of "Knowledge Exchange" indicators found in the report's chapter on "linkages and collaboration." In contrast to the UK presentation of similar data, the Australian table includes comparisons with other jurisdictions.

The Australian federal government is stepping up its efforts to measure U-B collaboration. For instance, the federal Department of Innovation, Industry Science and Research recently entered into a new arrangement with Knowledge Commercialisation Australasia (KCA - which represents organizations and individuals associated with knowledge transfer across public and private sectors). Beginning with the National Survey of Research Commercialisation in 2010, a joint approach will be taken as to how the Australian research sector – including KCA's membership - will be surveyed by the respective organizations.

Research (Inspiring Australia). The Labour Party's election commitment was to: "…invest $21 million in Inspiring Australia, the country's first ever national strategy for science engagement. Australia's future prosperity and wellbeing depend on our ability to create and apply science. This isn't just a challenge for scientists; it is a challenge for the nation."(Labor Party of Australia, 2010: 2).

Table 18
Australia's Performance in Knowledge Exchange vs. other OECD countries

Indicators	Latest Figure	Reference Year	OECD Ranking	Gap from the Top 5 OECD Performers
Proportion of innovation-active businesses collaborating with universities	1.6%	2006-07	-	
Proportion of innovation-active businesses collaborating with Publicly-funded research agencies*	7.2%	2006-07	-	
Proportion of SMEs collaborating in innovation with higher education institutions	3.1%	2004-06	13th	62.6%
Proportion of SMEs collaborating in innovation with government institutions	2.9%	2004-06	9th	49.2%
Proportion of large firms collaborating in innovation with higher education institutions	10.0%	2004-06	20th	75.8%
Proportion of large firms collaborating in innovation with government institutions	5.8%	2004-06	22nd	79.6%
Proportion of Australian-authored papers co-authored by researchers from more than one Australian research institution.	31.0%	2001-05	-	
Gross income from Licences, Options and Assignments by publicly-funded research organizations and universities.	$214m	2007	-	
Gross income from contracted research by publicly funded research organizations and universities	$1.23B	2007	-	
Start-up companies in which publicly funded research organizations and universities have an equity holding	205	2007	-	
Share of patents owned by universities and government	7.0%	2003-05	8th	27.1%
Proportion of HERD financed by business	6.7%	2006	12th	56.8%
Proportion of GOVERD financed by business	12.1%	2006	7th	23.7%

Source: Australian Innovation System Report 2010. Commonwealth Government of Australia, Department of Innovation, Industry, Science and Research (CGOA, 2010c).

Notes: See source document for data sources and footnotes. GOVERD refers to Government Expenditures on Research and Development. HERD refers to Higher Education Research and Development.

7.3 Australian Governments as Enablers

7.3.1 Intermediary Organizations

As with other countries examined in this report, Australian governments have supported a number of intermediary organizations whose functions include enabling U-B research collaboration, Again, they are presented below under the sub-categories of sectoral and horizontal organizations.

7.3.1.2 Sectoral Organizations

Rural Research and Development Corporations (RDCs)

The 1989 *Primary Industries and Energy Research and Development (PIERD) Act* established the RDCs on a statutory basis. The RDCs: help set priorities reflecting industry identified needs and government priorities; purchase research services from providers (including universities and the federal government's Commonwealth Scientific and Industrial Research Organization); and communicate research findings to industry (Frontier Economics, 2006). The federal government collects industry levies and contributes its own funding to the RDCs of up to 0.5 per cent of industry gross value of production. Of the A$ 1.5 billion spent in 2008-2009 by all Australian R&D performing sectors on rural related R&D, the RDCs account for A$ 218 million or just under 15 percent. According to the Australian Productivity Commission:

> "There are currently 15 RDCs — 6 statutory corporations and 9 industry-owned corporations (IOCs). All bar one cover single (though often broad) rural industries (for example, horticulture and grains). The exception is the Rural Industries RDC (RIRDC) which covers several smaller rural industries, as well as sponsoring research on 'national rural issues'. (Land and Water Australia, which ceased operations at the end of 2009, was also a non-industry-specific entity.) …The RDCs are governed by boards, as well as being subject to various planning, consultation and reporting requirements imposed by the Government as a quid pro quo for its funding contribution. However, while often characterised as a single model, there are considerable differences in the RDCs' functions, funding and governance arrangements. …A key difference is between the statutory corporations and the IOCs. The former are solely responsible for funding R&D and related extension activity, and operate under the Primary Industries and Energy Research and Development Act 1989 (the PIERD Act). In contrast, the IOCs also have marketing and, in some cases, industry representation functions." (CGOA, 2010g: xvii).

The major suppliers of R&D to the RDCs in 2008-09 were State and Territory Government entities (35 per cent), followed by the universities (30 per cent), private sector (20 per cent) and the Commonwealth Scientific and Industrial Research Organization (15 per cent). (CGOA, 2010g). Although universities receive only 20 percent RDC funding allocations, for some universities, and some faculties within those universities, RDC funds are an important source of research income.[155] The relationship between Australia's RDCs and universities represents an unusual juxtaposition of two very different institutions: those designed to restrict "R&D free riders" through levy arrangements with their client base (the RDCs); and institutions dedicated to "free and open inquiry" (universities).

The future role of the RDCs has been the subject of an inquiry requested by the federal government from the Australian Productivity Commission (APC). Although the relationship between the RDCs and the university sector was not the inquiry's main focus of attention, universities took a keen interest in the future of the RDC "model". Their submissions to the inquiry supported the RDC "model" (including, at least up to a point, its objective of excluding R&D free-riders), but they also suggested that the value of fundamental research should be taken into account. Three examples of the views expressed to the APC by Australian universities are:

- **The Australian National University said**: "The Rural Research and Development Corporations provide an important link in the R&D system between researchers, policy makers, and end-users of research. It is important to recognize the importance of such intermediate agents and 'honest brokers" within the R&D system." But also that: "Better articulated priorities from RDCs would provide a clearer path for industry engagement perhaps similar to the ARC Linkage model. This demand driven research should be complemented by funding set aside for inquiry-driven blue sky research. This produces two funding streams - 1) demand driven with defined outcomes and shorter timeframes to realisation; 2) enquiry driven with uncertain outcomes and longer timeframes to realisation but potentially greater rewards." (Australian National University, 2010: 7).

- **The University of Melbourne said**: "We are generally comfortable with the overall structure of the RDC system…" But also that: "In terms of investment strategies, we wish to see increased number of competitive calls with longer term strategies. There is a significant need to keep some stability in strategic research direction, and we recognise that Governments are not always able to maintain a long term direction for research given shorter term frameworks of the political system. In addition, the private sector is often limited in its capacity to tackle long term problems where significant investment is required. In our direct experience, this lack of longer term research strategic direction has resulted in the loss of capacity, where highly skilled researchers have left the country and, in some cases, their research careers. These cases

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[155] For example, the University of Adelaide, in its June 2010 submission to the inquiry, said: "Research income from RDCs to the University of Adelaide comprise a significant proportion of our National Competitive Grants ('Category 1') research income. In 2008, grants from RDCs accounted for 17.6 percent of our Category 1 income (and 8.5 percent of our total research income). This percentage was even higher in the previous year (22 percent)." (University of Adelaide, 2010: 2).

are directly related to the difficulty in maintaining continuity of research funding." (University of Melbourne, 2010: 3).

- **The University of Adelaide said:** "While the overarching RDC model provides a good long-term source of research funding, unfortunately there are concerns that support for individual projects can sometimes be too short-term due to a perceived need by the RDCs to satisfy the levy payers. This can lead to projects which avoid potentially transformational research, the related questions of which may take 5 years or more to solve. This type of research is often the first to be stopped if funding gets tight, so major breakthroughs are less likely." (University of Adelaide, 2010: 5).

The APC published its draft report on the RDCs in September 2010. The draft report takes note of various strengths in the RDC model, including its intermediary characterstics: "By virtue of their research brokering function and the large amount of cash funding they have at their disposal, the RDCs play a valuable 'systems integrating' role. For example, their capacity to influence the projects funded through other rural R&D programs has helped to prevent wasteful duplication of research effort." (COGA, 2010g: xx). However, the draft report states that a significant part of the federal government's funding contribution to the RDC's appears to have supported R&D that primary producers would have had sound financial reasons to fund themselves.

The draft APC report recommends a reduction of federal government contribution to the RDCs and reallocation of those resources to a new organization (operating at arms length from government) dedicated to funding broader rural research that is likely to be under-provided by industry-specific RDCs rural research."[156] The APC considered and rejected other options largely because they would weaken rather than strengthen the linkages between producers and the Australian research base. The draft report states:

- Reallocating the Australian Government's current funding contribution to the RDCs to either CSIRO or the universities would lessen interaction with primary producers, leading to fewer reality checks on the worth of R&D and slower uptake of research outputs. There would also be less competition in the supply of the research concerned.

- Reallocating the Government's contribution to departmental programs would similarly lessen interaction with primary producers and would also require new and potentially costly mechanisms to channel funds to research suppliers.

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[156] The draft APC report recommends that: "A new, government-funded, RDC — Rural Research Australia (RRA) — should be created to sponsor broader rural research that is likely to be under-provided by industry-specific RDCs. The Government's funding appropriation for RRA should be progressively built up to around $50 million a year; [and] The industry-specific RDCs should focus predominantly on R&D of direct benefit to their levy payers — but with the cap on the Government's funding contribution gradually reduced to half its current level over 10 years. (APC, 2010: xiv).

Deficiencies in program management skills within some government departments could further detract from the outcomes delivered by this approach.

- Relying solely on the generally available R&D tax concession would be problematic on practical grounds, as well as giving rise to some more fundamental efficiency and transitional concerns. (CGOA, 2010g: 125).

Enterprise Connect Manufacturing and Innovation Centres

The federal government's May 2008 budget announced that a new *Enterprise Connect* program would be established:

> "This Government will provide $250.7 million over five years to establish ten Enterprise Connect Innovation Centres around Australia. The centres will provide business and advisory and diagnostic services targeted at assisting small and medium businesses improve their productivity and capacity for innovation. Funding will establish Industry Innovation Councils for key sectors to support the Enterprise Connect network; and provide resources for establishing governance and administration arrangements to bring responsibility for innovation, industry, science and research within the one Department. Funds have also been allocated for the employment of a full time chief scientist." (CGOA, 2008b).

As of January 2011, the federal government had established six innovation centres (in the areas of Creative Industries; Clean Energy; Innovative Regions; Resources Technology; Remote Enterprise; and Defence) and six manufacturing centres. The primary objective of these centres is to deliver funding to SMEs to reduce their cost of finding and acquiring "knowledge and expertise" to and thereby help them "transform and reach their full potential." (Enterprise Connect, 2010, Web).

The program offers firms a variety of services, starting with a free "business review" conducted by expert advisers. After a business review is completed, the Australian Government offers matching grants of up to A$ 20 thousand to address areas identified by the business review for improvement and growth through an advisory service which draws on expertise of "partner organizations". The partner organizations vary according to the individual centres, but include chambers of commerce and commercialization networks (e.g. the Industry Capability Networks in Queensland and Victoria).

Encouraging U-B collaboration is not a formal objective of the program, but in design and operation it has that effect. Four of the six manufacturing centres are located on or closely adjacent to Australian universities (e.g., the centres located at Melbourne, Adelaide, Burnie, and Brisbane). Among the Innovation Centres, the Creative Industries Centres is hosted by the University of Technology in Sydney while the Clean Energy Innovation Centre is hosted by Newcastle Innovation, a commercial arm of the University of Newcastle.

Industry Innovation Councils

Since 2009, eight Industry Innovation Councils have been established by the federal Minister for Innovation, Industry, Science and Research. Although the mandate of the councils is much broader than U-B collaboration, each council includes industry and university representatives. An Industry Innovation Councils Framework, issued in March 2010 by the Minister for Innovation, Industry, Science and Research, sets out in greater detail the federal government's expectations for how the councils will operate and what they will achieve, including: "building linkages and collaboration among innovation stakeholders to bridge gaps between business and research." (CGOA, 2010b: 3).

7.3.1.2 Horizontal Organizations

The Australian Institute for Commercialisation (AIC), (Queensland State Government)

In 1998 the Queensland state government began development of a "smart state" plan to diversify the state economy and to promote innovation within traditional industries. As part of the plan, the AIC was established as a not-for-profit company in 2002 and with initial funding of A$ 10 million over five years. The AIC's original objective was to:

> "…work with Commonwealth and State governments, the research community and industry to identify issues inhibiting commercialisation. It is working to improve networks, promote educational and cultural change, advocate the importance of commercialisation, and provide practical project assistance and advice to firms." (Government of the State of Queensland, 2003: 83)

In 2003 the AIC reported that it would not duplicate programs with other agencies or organizations and that its intent was to: "…co-ordinate activities for greater effectiveness and efficiency on a national level, responding to areas of market failure." (Australian Institute for Commercialisation, 2003: 2) Over the years since its start-up, the AIC has received additional funding from the federal government, other state governments, the Northern Territory and various research institutions. It has also expanded the range of its activities. For instance, it has help deliver some federal and state government commercialization programs.

The Business, Industry Higher Education Collaboration Council (BIHECC, 2004-2008)

BIHECC was established by the federal Minister for Education, Science and Training in July 2004. In its Backing Australia's Ability (2004) policy statement, the federal government stated that:

> "The Business/ Industry/ Higher Education Collaboration Council (BIHECC) and the Collaboration and Structural Reform Fund were created in response to the need for greater collaboration and communication between higher education and business and industry, and between higher education institutions. BIHECC's mission is to increase collaboration within the higher education sector and

> between higher education and business, industry, vocational education and training and regional/community organisations." (CGOA, 2004: 108)

The BIHECC also had an advisory mandate with respect to the allocation of the collaboration and structural reform fund. This A$ 41 million fund was established in 2005 by the federal government under Prime Minister John Howard. According to the Ministry of Education, Science and Training: "The fund provides competitive funds to foster collaboration between higher education institutions and business, other education sectors (including the vocational and technical education sector), professional associations and community groups." (CGOA, 2005a: 84)

Between 2004 and 2008, the BIHECC met eleven times and commissioned a number of reports for the federal government. In 2008 the BIHECC announced its own end: "While the niche occupied by BIHECC is an important one, the Council in its current form has run its course and other models for formal interaction between the sectors should be considered."(CGOA, 2008a: 4)

In the event, the federal government did not to renew the BIHECC perhaps in part because the government was planning to introduce new Industry Innovation Councils. Perhaps not coincidentally, however, the BIHECC's end came just as the "Collaboration and Structural Adjustment Fund" was being rolled into a broader "Diversity and Structural Adjustment Fund which had different objectives. (as noted earlier, Australian universities and businesses established and funded a Business Higher Education Round Table in 1990 – a forum that continues to exist and deliver value to its sponsors to this day).

National Industry Skills Councils

Australia has eleven Industry Skills Councils (ISCs) which are: recognized and funded by the Australian Government; governed by independent, industry led boards; and are legally constituted not-for-profit companies limited by guarantee. In the past the ISCs have generally focused most of their attention and resources on the vocational and educational training (VET) sector rather than the higher education sector. They are now broadening the scope of their interests. For example, John Vines, Chair of the Innovation Business Skills Sector Council (responsible for six industry sectors, including financial services, information and communications technologies, and cultural and creative industries) has stated:

> "The skills needs of industry, and individuals, are transferred as responsibilities or outputs from the secondary schools, national VET and higher education systems. While the national VET system has most attention in this environment scan, the importance of connecting the VET and higher education sectors manifests in our attention to a 'whole of learning and skilling' environment." (Vines, 2010:1)

In a July 2010 submission to an Australian Senate inquiry into ISCs, Glenn Withers, the Chief Executive Officer of Universities Australia (the association representing Australia's universities), called for stronger relationship between the ISCs and the university sector (Withers, 2010).

The Australian Chamber of Commerce and Industry (ACCI) strongly supports the ISCs and has stated that they play "an integral role in Australia's industry led training system." The ACCI has also voiced concern that the ISC's were being diverted from their main mission through being asked to deliver on specific government programs. (Australian Chamber of Commerce and Industry, 2010: 11)

7.3.2 Other Enabling Measures

Researchers in Business

The Australian federal government has supported a variety of U-B collaborative training/research programs. The *Researchers in Business* program was launched in May of 2008 as part of a broader *Enterprise Connect* initiative. The program supports the placement of researchers from universities or public research agencies into businesses to help develop and implement new commercial ideas. Funding is provided for up to 50 per cent of salary costs to a maximum of A$ 50,000 for each placement and for durations of up to 12 months. The policy rationale for the program is that:

> "For too long, Australia has ranked last in the OECD on collaboration between public sector researchers and industry. This costs us opportunities and leaves us falling further and further behind the rest of the world. Researchers in Business is one of a number of measures to boost the kind of collaboration that will make the most of great Australian ideas and make the most of the taxpayer's investment in higher education." (CGOA, 2009j).

The A$ 10 million (over five years) provided to the *Researchers in Business* program stands in contrast to A$ 2.5 billion (over ten years) funding provided by the federal government for its Trade Training Centres in Schools initiative also announced in the 2008 federal budget.

7.4 Australian Governments as Funders

Examples of federal government policy instruments for encouraging U-B collaboration through funding are presented below under three headings: (a) research funding conditions; (b) research funding programs and institutions; and, (c) other fiscal incentives (i.e., the Australian R&D Tax Credit).

7.4.1 Funding Conditions

Institutional Grant Scheme (IGS), the Joint Research Engagement Program, and the Collaborative Research Networks Scheme

Up until 2009, Australia's IGS block scheme provided grants to universities to support research and research training. In the past, the granting process gave a weight of 60 percent to third-party funds ("research income"), 30 percent to teaching load, and another 10 percent to research publications. The policy intent of this weighting at the time of its introduction in 1999 was to incent universities to seek out third-party funding (CGOA, 1999: 16). The IGS formula included competitively awarded research grants (e.g. from the Australian Research Council) as "third-party" funding. This came to be perceived by the federal government as incenting universities to vigorously pursue grant funding rather than other third-party funding.

In May of 2009, the federal Minister for Education, Training and Youth Affairs announced a separate "Joint Research Engagement" program (see text box next page) that would be separate from the IGS block grants. The formula for calculating awards under the Joint Research Engagement program do not include competitively awarded research grants. The federal government stated:

> "The Government will redirect $1.2 billion over four years (including $158.8 million in 2009-10, $323.9 million in 2010-11, $330.0 million in 2011-12 and $337.6 million in 2012-13) from the Institutional Grants Scheme for a new Joint Research Engagement program. The new program will use a revised allocation formula which removes competitive grant income as a driver of funding. This change is intended to give greater emphasis to end-user research by encouraging and supporting collaborative research activities between universities, industry and end-users." (CGOA, 2009a: 358).

Australia's Joint Research Engagement Program (2009) Budget Fact Sheet

"This program transforms the Institutional Grants Scheme (IGS) to encourage greater collaboration between universities and the business and non-government research sectors – an area in which Australia performs extremely poorly by international standards.

The Joint Research Engagement initiative involves revising the IGS funding formula to remove competitive research grant income from the calculations used to allocate this research block grant, thereby rewarding universities which diversify their sources of research income.

This initiative is a companion reform to the Sustainable Research Excellence in Universities initiative and the Collaborative Research Networks program. Together they form a comprehensive suite of support that will enable universities to build capacity to successfully undertake the basic and industry driven research that forms the foundation of Australia's innovation system.

Facts and Figures:

- Currently the IGS supports the general fabric of higher education institutions' research and research training activities. Institutions have discretion in the way they spend their IGS grant, provided it is used to fund any activity related to research.

- The Joint Research Engagement funding will continue to support soft infrastructure as well as the maintenance of capital items (not capital purchases), but will change the way that the level of funding for each university is calculated.

- The current methodology for calculating the funding for each university is based on a formula that includes the amount of funding raised from competitive grants. This tends to create a focus on research that is already being funded through competitive grants, and which receives support for indirect costs through the Research Infrastructure Block Grant Scheme.

- To address this, a revised formula will be developed in consultation with the sector that removes the existing necessity for universities to rely on the receipt of funds from a competitive grants program and instead rewards them for attracting funds from other sources, including industry and community partners and public sector research agencies.

- The new formula will give greater emphasis to end-user research by encouraging and supporting collaborative research activities between universities, industry and end-users, beyond those specifically supported by competitive grants.

- Funding will be allocated on the basis of demonstrated research excellence and ability to attract funding from other sources. This initiative is cost neutral as it involves refocusing the existing funding available through the IGS. This program is expected to commence in the 2010 academic year, following consultation with the university sector on its implementation."

Source: Department of Innovation, Industry, Science and Research (2009).
www.innovation.gov.au/.../jointresearch_budgetfactsheet0910.pdf

In 2010, the federal government also introduced a Collaborative Research Network (CRN program. The CRN Program will provide up to A$ 51 million from January 2011 until mid- 2013 to encourage less research-intensive, smaller and regional universities to strengthen their research capacity by teaming up with other institutions in areas of common interest. However, the federal government's Innovation, Industry, Science and Research links the program to a U-B collaboration policy theme, stating that:

> "Smaller and regional universities often have strong links with local businesses and communities, and much of their research is addressed towards regional needs and priorities. CRN will help them to increase their collaboration with local business and industry as well as other universities." (CGOA, 2010c: 66).

The Australia Research Council (ARC) National Competitive Grants

ARC is a statutory authority within the Australian Government's Innovation, Industry, Science and Research portfolio. The ARC is responsible for delivering the National Competitive Grants Program (NCGP) funded at a level of A$ 652 million in 2009-2010.

The two main sub-programs of the NCGP are Discovery and Linkage. The Discovery sub-program flows funding (A$ 381 million in 2009-2010) on a peer-reviewed basis to individual researchers. It also supports a variety of fellowship programs. Linkage funding (A$ 271 million in 2009-2010) flow for: collaborative research infrastructure;[157] collaborative research projects (Linkage Projects); and Centres of Excellence,

The objective of Linkage Projects is to encourage and develop long-term strategic research alliances between higher education organisations and other organisations, including business. Proposals for funding must involve an organization from outside the higher education sector (i.e., from the private or public sectors or from a community organization). Such organizations must make a significant contribution in cash and/or in kind, to the project that is equal to, or greater than, the ARC funding. Over recent years, companies have represented 40 percent of the partner organizations involved in linkage projects. Over the 2007-2009 period, almost 1,300 awards were made totaling almost A$ 400 million. (CGOA, 2009: 197).

ARC's Centres of Excellence began operation in 2003 and are analogous to the Canadian Networks of Centres of Excellence. The ARC centres: "undertake highly innovative research at the forefront of developments within areas of national importance, with a scale and a focus leading to outstanding international and national recognition"; and

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[157] ARC's Linkage Infrastructure, Equipment and Facilities (LIEF) program supports the purchase of medium-cost research infrastructure and equipment (over A$ 100 000 in value - universities generally fund smaller equipment purchases while funding for large scale equipment, infrastructure and facilities is provided through Australia's National Collaborative Research Infrastructure Strategy). The selection criteria for LIEF projects assign a 30 percent weight to strength and benefits of collaboration between eligible organizations. Over the 2007-2009 period, 220 LIEF awards were made totaling almost A$ 100 million. (A separate funding arrangement is in place for international research infrastructure).

"serve as points of interaction among higher education institutions, Governments, industry and the private sector generally." (CGOA, 2008) In 2002 ARC distinguished the new centres from other programs, most particularly Australia's Cooperative Research Centres, in the following terms:

> "Linkage Priority Centres of Excellence will build on the ARC's experiences with its successful programs for Special Research Centres and Key Centres of Teaching and Research. They will differ from the Government's Cooperative Research Centres by permitting greater flexibility in commercialisation models and in their interaction with industry participants, by being less prescriptive regarding the legal nature of the Centre operator, and by undertaking a large fraction of research at the basic and pre-competitive stages." (CGOA, 2002a: 5)

The ARC Centres have generally not been a target of any loud criticism but neither have they been subject to any extensive review. They were given only passing mention in Australia's 2008 review of its innovation system and in the federal government's 2009 innovation agenda, and in both cases they were offered as examples of the benefits of "collaboration." Through to January 2011, three rounds of competition for centre funding have been held.

Excellence in Research in Australia (ERA) Initiative

Australia's ERA initiative is intended to assess research quality within Australia's higher education institutions using a combination of indicators and expert review. The initiative has been funded to a level of A$ 35.8 million over four years starting in 2008. The Minister of Innovation, Industry, Science and Research said in his February 2008 ERA launch announcement that:

> "It [the ERA] will also assist with the Government's plans to introduce funding compacts for universities." (CGOA, 2008d).

Nonetheless, perhaps reflecting the political sensitivity in Australia of linking funding to engagement targets, no direct connection has yet been made between the ERA and the proposed university funding compacts or to the allocation criteria under development for the A$ 206 million Higher Education Performance Fund.[158] Since the Minister made his February 2008 ERA launch announcement, no further reference to any linkages between the ERA and higher education funding allocations have been made. Instead, the ERA's

[158] The federal government's 2009 higher education policy statement, *Transforming Australia's Higher Education System*, said that one element of the funding compacts would be the introduction of A$ 206 million over four years of performance funding: "Performance Funding: To ensure that Australia's reputation for quality remains high, the Government will introduce at-risk performance funding for universities from 2012. …The Government intends to hold higher education institutions accountable for the significant public investment in the sector. One of the main ways of doing this will be through the use of a new funding stream to ensure universities meet agreed attainment, participation, engagement and quality targets."

objectives are described in such terms as "Establish an evaluation framework that gives government, industry, business and the wider community assurance of the excellence of research conducted in Australia's institutions." (CGOA, 2010a). This has drawn the attention of the Australian Industry Group (2010)[159] which has stated:

> "…the incentives facing researchers at the individual level to engage with industry are limited by the Excellence in Research for Australia (ERA) framework, which defines impact primarily in terms of academic publications. This structure necessarily focuses attention away from engagement with business to apply knowledge and develop solutions to real-world problems, as promotion opportunities are tightly linked to teaching and publication outcomes." (Australian Industry Group, 2010: 13)

7.4.2 Other Research Funding Programs

Co-operative Research Centres (CRCs)

The Cooperative Research Centres Program was established by the federal government in 1990 and is administered by the federal Department of Innovation, Science and Research (DISR). According to DISR:

> "A CRC is formed through a collaboration of businesses, community-sector and government organisations and researchers. This includes private sector organizations (both large and small enterprises), industry associations, universities and government research agencies such as the Commonwealth scientific and industrial research organisation (CSIRO). Essential participants must include, at any one time, at least one Australian end-user (either from the private, public or community sector) and one Australian higher education institution (or a research institute affiliated with a university). The CRC enters into a funding agreement with the Australian Government. The agreement sets out the activities, milestones and outputs of the proposed research programs, the milestones for the utilisation of these research outputs and the impacts and expected benefits of the CRC as well as the financial requirements for CRCs." (DIISR, 2010 Web).

Since 1990 185 CRCs have been funded and, today, 48 CRCs are operating in six sectors: manufacturing technology; information and communication technology; mining and energy; agriculture and rural-based manufacturing; environment; and medical science and technology.[160] The total investment by Australian federal governments in the CRC program between 1990 and 2010 has been A$ 3.3 billion. (CGOA, 2010c: 65)

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[159] As previously mentioned, the Australian Industry Group is an Australian industry association created through the merger in 1998 of the Australian Metals Trades Association and the Australian Chamber of Manufacturers.

[160] A fourteenth CRC selection round is underway, with applications in the areas of clean manufacturing, social innovation and sustainable regional communities being "encouraged."

The federal government commissioned a major review of the CRC program which was completed in 2008 (O'Kane). The review's final report, *Collaborating to a Purpose*, recommended the program be continued but a number of its recommendations drew a strong response for the Co-operative Research Centres Association (CRCA). The CRCA expressed concern that:

> "Core partners must make real, solid contributions to their CRC. Very careful consideration needs to given to the funding and in-kind guidelines for Universities. Feedback from non-university partners is strongly of the view that universities still need to contribute more than on a fee-for-service basis or else they will jeopardise their partnership status and weaken the fundamentals of the CRC Program." (Co-operative Research Centres Association, 2008: 2).

The CRC Association also drew attention to the more general issue of achieving coherence between policies for encouraging collaboration (such as within the CRC program) and other research granting policies (such as within the competitive grants program). (Co-operative Research Centres Association, 2008: 3).

The federal government's own response to the O'Kane report, as broadly set out in its 2009 *Power Ideas Innovation Agenda,* was to make a commitment to: "Renew the Cooperative Research Centres Program along the lines proposed in Collaborating to a Purpose — building on the new program guidelines released in 2008, which reinstate public good as a funding criterion, encourage research in the humanities, arts and social sciences, and increase the program's focus on the needs of end-users." (CGOA, 2009i: 8).

Commonwealth Scientific and Industrial Research Organization (CSIRO) and its National Research Flagship Program.

CSIRO's primary functions, as set out under the *Science and Industry Research Act* (1949), include carrying out scientific research to assist Australian industry and "encourage or facilitate the application or utilization of the results of such research" CSIRO's total revenue in 2008-2009 were A$ 1.3 billion, including: A$ 668 million from the federal government; and A$ 634.8 from other external sources (e.g., consulting and research services provided to Australian government departments (A$ 148.3 million) and private sector (A$ 76.3 million).

CSIRO has in place a range of programs whose objectives include encouraging research collaboration, and often U-B research collaboration. The largest of these is its National Research Flagships Program launched in 2003. Total federal government funding for the initiative since its launch is almost $A 2 billion.

There are ten National Research Flagships. The original six launched in 2003, an additional three announced in 2007 and one in 2009.[161] Flagships are targeted at

[161] The ten flagships are: Preventative Health; Light Metals; Food Futures; Energy Transformed; Water for a Healthy Country; Wealth from Oceans; Climate Adaptation; Future Manufacturing; Minerals Down Under; and Sustainable Agriculture.

supporting collaborative research aligned with the Australian Government's National Research Priorities. Each Flagship involves collaboration between leading Australian scientists, research institutions, commercial companies and CSIRO. In effect, they encourage U-B collaboration.[162] A Flagship Clusters program element supports larger scale activities over long time periods (CGOA, 2010h: 3). A Flagship Advisory Committee (not "industry-led" but composed of industry, academic and government experts) is attached to each Flagship to ensure: "a planned program of research and development for each Flagship that is responsive to the strategic research needs of industry and society." (CSIRO. Web. Accessed August 2010).

Commercialisation Australia

In early 2010 the federal government launched a new organization for delivery of its research commercialization programs and services: Commercialisation Australia. Commercialisation Australia has funding of A$ 244 million over the five years FY 2010 - 2014, with ongoing funding of A$ 82 million a year thereafter. The Commercialisation Australia program guidelines issued by the Minister of Industry, Innovation, Science and Research in 2009 state that:

> "The policy objective of the Commercialisation Australia program is to build the capacity of, and opportunities for, Australia's researchers, entrepreneurs and innovative firms to convert ideas into successful commercial ventures, enhancing Australia's participation and competitiveness in the global economy and generating commercial returns from Australia's significant investment in public sector research. This is a response to systemic and market failures in the pathway to early stage commercialisation." (CGOA, 2009d: 2).

Commercialisation Australia reports that it delivers a range of commercialization programs and services, including:

- **Skills and Knowledge support** to help build the skills, knowledge and connections required to commercialise intellectual property, providing funding of up to A$ 50,000 to pay for specialist advice and services. This funding is provided in the ratio of 20 per cent contribution by the applicant to an 80 per cent contribution from the grant, to a maximum grant amount of A$ 50, 000 (e.g., A$ 12,500 from the applicant and A$ 50,000 from the grant).

- **Experienced Executives grants** which provides funding up to A$ 200,000 over two years to assist with the recruitment of a Chief Executive Officer or other senior executive. This assistance is provided on a 50:50 matching basis.

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[162] CSIRO's Flagship Funding Guidelines (2010) state that: applications for projects and clusters will be accepted from publicly-funded research institutions, both in Australia and overseas. This includes universities, Cooperative Research Centres (CRCs), other Australian PFRAs [Publically Funded Research Agencies] (excluding CSIRO) and other publicly funded and not-for-profit research institutions.

- **Proof of Concept grants** of A$ 50,000 to A$ 250,000 to test the commercial viability of a new product, process or service. This assistance is provided on a 50:50 matching basis.

- **Early Stage Commercialisation repayable grants** of A$ 250,000 to A$ 2 million to develop a new product, process or service to the stage where it can be taken to market. This assistance is provided on a 50:50 matching basis. (Commercialisation Australia, Web, Accessed January 2011).

Applications for funding assistance are judged against five merit criteria: need for funding; commercial plan and potential; market opportunity; management capability; and national benefits. The last criterion, national benefits, is broadly defined to include improving Australia's participation and competitiveness in the global economy but also increased collaboration between businesses and/or businesses and research institutions (including universities).

Commercialisation Australia has a seven member Board (not a Board of Directors). In legal form, the Board is a committee of Innovation Australia (Innovation Australia is a statutory body established in 2007 to assist with the administration of the Australian Government's innovation and venture capital programs).

The CA Board is chaired by Dr. Laurie Hammond, a scientist and founder of a venture capital group. The board also includes: a university official; a member of the Australian Manufacturing Workers Union; a CSIRO official; two individuals from the private sector; and the CEO of Commercialisation Australia. According to Commercialization Australia, the board actively involves itself in assessment of applications for assistance: "Board members are equipped with the technical and commercial expertise to assess and provide advice on the merit of applications." (Commercialisation Australia, Web, Accessed January 2011).

Commercialization Australia is not truly at "arms-length" from the federal government although it has some degree of operating independence. The 2009 Commercialisation Australia program guidelines state that:

> "The Secretary of the Department [of Industry, Innovation, Science and Research] will appoint a Chief Executive Office (CEO) of the Commercialization program. The CEO will retain an ex-officio position on the Commercialisation Australia Board. …The CEO must have regard to the policy objective of the Commercialisation Australia program when performing any function or making any decision in relation to the program." (CGOA, 2009d: 7).

Defence Future Capability Technology Centre (DFCTC) Program

In 2007 the Australian federal government issued a *Defence and Industry Policy Statement*. The statement contained a commitment to:

> "More R&D collaboration between DSTO [Defence Science and Technology Organization], industry and universities: Given the size of Australia's R&D base, there is potential benefit to be gained by further pooling the expertise and resources of DSTO, industry, universities and other public research bodies to develop defence technology for the ADF [Australian Defence Force]. To achieve this objective, the Government will initiate a program of joint defence research ventures in 2008. Modelled on the Government's existing program of Cooperative Research Centres and the successful CSIRO Flagship Collaboration Fund, but adapted to the specific needs and constraints of the defence sector, the program will operate on a fully-competitive basis." (CGOA, 2007: 29).

In May 2008 the first Defence Materials Technology Centre (DMTC) under the DFCTC program was established. DMTC funding includes: an A$ 30 million contribution from the federal government; a combined A$ 9 million contribution from the state governments of Victoria, Queensland and New South Wales; and an expected contribution of $A 46 million from industry and research sector participants. The DMTC is supported by 29 organizations, including five Australian universities. DMTC operates as a public company, limited by guarantee, and is funded for an initial seven-year term.

Voucher Programs

Australian state governments are beginning to introduce various voucher programs. For instance, the New South Wales (NSW) government operates a $A 1.4 million *TechVouchers* program that provides NSW small and medium enterprises with funding to access public research infrastructure and technical expertise, to undertake collaborative projects with public research organizations (including universities) and third party service providers.

One design feature of the NSW voucher program (and that sets it apart from other voucher programs described in earlier sections of this report) is that not only does it provide vouchers to NSW SMEs, but also provides for grants to NSW public research organizations to implement the voucher program. According to program guidelines, grants of up to A$ 50,000 are available to subsidize up to 50 per cent of the salary of an employee (a 'Connector') who will work to map the organization's capabilities and facilitate engagement with SMEs for one year. Between up to ten organisations will be awarded these grants. (Government of New South Wales, 2010, Web). Five of the six successful public research organizations applying for the first round of these grants in 2010 were universities with the other grant recipient being CSIRO's Material Sciences and Engineering centre.

7.4.3 Other Fiscal Incentives

The Australian R&D Tax Credit

The federal government's May 2009 budget announced that the Government will replace the existing R&D Tax Concession with a new R&D Tax Credit.[163] The new R&D Tax Credit includes a 45 per cent refundable tax credit (the equivalent to a 150 percent concession) for companies with an aggregate turnover of less than A$ 20 million per annum; and a 40 percent non-refundable tax credit for all other eligible entities. The detailed design of the new tax credit was the subject of a long consultation process and competing views on what should be an eligible activity and who should be eligible.[164]

In 2008, Universities Australia expressed its strong support for reform of the existing R&D tax concession. The second exposure draft of the tax credit legislation has been well received by at least one university organization in part because it permitted companies partly or wholly owned by universities. Charles Day, CEO of Melbourne Ventures (a technology commercialization company wholly owned by the University of Melbourne) has stated that:

> "We also welcome the proposal that tax exempt entities may now hold up to 50% of a company before the entitlement to the Refundable Tax Credit is removed, compared to the current cap of 25%. It is not uncommon at the very early stage of a company's life, before venture capital funding is received, that universities will hold more than 25% equity, and this is exactly the time when refundable R&D credits may be most valuable to the company's survival. The new 50 percent cap will improve the workability of this rule in practice." (Day, 2010: 2).

7.5 Australian Governments as Rule-makers

Three examples of the Australian federal government exercising its authority as rule-maker to encourage U-B collaboration (but often as part of an effort to achieve other and broader policy objectives) are in the areas of intellectual property; the regulatory system for Australian clinical trials; and federal government "mission-based" compacts under negotiation with Australian universities.

7.5.1 Intellectual Property (IP)

The treatment of IP in university settings has increasingly attracted the attention of Australian governments, universities and businesses. The federal government's 2009 *Powering Ideas* agenda emphasizes a need to improve IP management processes:

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[163] The federal government introduced bills to establish the R&D Tax Credit on September 30th, 2010. As of January 2011, the bills were still before the Australian Parliament. The bills propose that the R&D Tax Credit apply to income years starting on or after 1 July 2010.

[164] The new tax credit includes: a non-refundable 40 per cent R&D tax offset; a 45 per cent refundable R&D tax offset for (broadly) R&D entities with an aggregated turnover of less than A$ 20 million; the creation of two categories of R&D activity for the purposes of defining eligible R&D expenses: core and supporting; and the broadening of organizations eligible for the tax credit from Australian corporations and public trading trusts to Australian-incorporated companies, including both Australian-owned and foreign-owned companies. The tax credit will be open to companies with up to 50 per cent ownership by exempt entities (such as universities).

> "Given the legal and technical complexity of the intellectual property system, the Commonwealth will not make changes without consulting fully with stakeholders. IP Australia has already started on this. In the meantime, the Commonwealth will improve intellectual property education for researchers and business. The government's aim is to ensure that new Australian ideas are translated into new wealth and new jobs for Australia. Raising the standard of intellectual property management will help us achieve that aim." (CGOA, 2009: 57).

The Australian Industry Group's report, *New Thinking New Directions* (2010) also suggests that the key IP issues relate to process rather than policy. The report states:

> "…the perception of issues related to intellectual property (IP) appears to constrain the willingness of some businesses to work with the research sector. However, the Review identified that in many cases these issues are perceived rather than actual, and problems associated with shared development and ownership of IP can in fact be readily solved. Issues with other transaction costs and the uncertainty of a return on investment are inherent in any collaborative venture. There are considerable opportunities for improvement in relationship management and contracting, however." (Australian Industry Group, 2010: 13).

Australian universities generally own the IP generated by their researchers. As described in a 2004 report commissioned by the Australian Vice-Chancellors Committee and the Australian Business Council, this is based on employers' entitlements, which arise through: terms in employment contracts/agreements or in policies to which the contract/agreement refers; by operation of a duty of fidelity that an employee has to an employer; or by operation of legislation/regulations (The Allan Consulting Group, 2004: 22). Nonetheless, the debate over the merits of various university/academic IP ownership models found in the US has also arisen in Australia. It was given prominence in 2009 as a result of a Federal Court of Australia decision that an employee of an educational institution was not required to advance the University's commercial interests and therefore, no such "duty to invent" could be read into his contract.[165] Although the full

[165] Boocock (2010: 1) reports that: "In September of 2009, the Federal Court of Australia considered whether the employer, the University of Western Australia (UWA), was entitled to own an invention of one of its employees, Dr. Bruce Gray. Under the terms of his appointment, Dr. Gray was required "to undertake research and to organize and generally stimulate research among the staff and students." A previous lower court decision considered the disputed ownership of a number of inventions relating to targeted treatments for cancer which were alleged to have been made by Dr. Gray during his term of employment with UWA2. On appeal, only one of these inventions was at issue. …The Full Court also affirmed the primary judge's decision that the wording of Dr. Gray's contract, which set out a "duty to conduct and stimulate research", did not imply a "duty to produce patentable inventions" in an academic setting. The Court reiterated the facts supporting this view. These facts included that Dr. Gray (i) was not bound by a non-disclosure agreement relating to his inventions, (ii) was expected to solicit external funds to support his research, and (iii) was expected to collaborate externally to further his research. The court found that UWA's primary function in education was not altered by its commercial ventures. Thus, Dr. Gray, as an employee of an educational institution, was not required to advance the University's commercial interests…."

implications of this decision have yet to be seen, some observers (e.g. Knowledge Commercialisation Australasia) consider that it has created new uncertainty that may require a federal government policy response.

7.5.2 Regulation of Clinical Trials

In December 2008 a government-appointed Pharmaceutical Industry Strategy Group had warned the federal government that emerging competition from low-cost centres continues to threaten Australia's long term competitiveness as a destination for pharmaceuticals clinical trials. The Group stated in the report's letter of transmittal that: "Local biotechnology companies will struggle to secure the funding required to develop their intellectual property, with more of Australia's promising medical science being commercialised offshore. This is not a future that will deliver high net economic or social benefits to Australia." (CGOA, 2008e).

In October of 2009, Australia's federal government created an Action Group to develop options to improve the Australian clinical trials operating environment. The Action Group's consultation papers, and the submissions received in response, suggest that government rule-making for the conduct of clinical trials (especially multi-site trials) may be one subject of attention within its June 2010 report to the Minister of Health and the Minister of Innovation, Industry, Science and Research (which has not yet been released to the public and to which – as of January 2011 - the government has not yet given a public response). For example, the Action Group's consultation paper on *Ensuring the Rapid Uptake of Streamlined Ethics, Scientific and Governance Review Process* states that:

> "Pharma believes that one of the most significant barriers to clinical trial investment in Australia is the increasing comparatively lengthy time taken to gain regulatory approval for multicentre clinical trials. Reforms in both of the following areas are most likely to reduce approvals times: (1) ethics and scientific review and (2) research governance review. Strategies to reduce approval times may also include concurrent reviews of ethics and science, and research governance…" (CGOA, 2009c: 4)

7.5.3 University Governance

The legal capacity of universities in Australia to engage in commercial activities is governed by university establishment acts at state government levels. These have been subject to revision in the past to permit greater flexibility for universities to engage in commercial activities. For example, the New South Wales Government amended its university acts in 2001 to clarify that New South Wales universities can engage in commercial activities. The New South Wales legislative amendments make provision for the State Education Minister, on the advice of the State Treasurer, to approve guidelines for university commercial activity. New South Wales universities develop and submit for approval their own draft guidelines suited to their individual strategic and operational needs (CGOA, 2002).

At the federal government level, in 2005 the Department of Education, Science and Training issued the consultation paper *Building Better Foundations for Higher Education in Australia* which sought to introduce improved university governance arrangements across the country through building on National Governance Protocols introduced by the Australian Government (CGOA, 2005: 4).

The federal government's most recent initiative to influence the direction of Australian universities, including in relation to governance issues, is the introduction of "mission based compacts" with universities (CGOA, 2009h). These three-year agreements between the federal government and individual universities are not solely directed at encouraging U-B collaboration (although they are closely linked to university access to A$ 550 million in "performance funding") They do, however, offer a new channel of federal influence to align university priorities with federal innovation policy priorities, including encouraging U-B collaboration. In October of 2010, the Honourable Kim Carr, federal Minister for Innovation, Industry, Science and Research, stated that:

> "The compact agreements will reflect the unique mission of our universities while contributing to a coordinated response to the Australian Government's goals for higher education, research and innovation. These goals include raising the performance of our university sector and participation in it, the excellence and sustainability of our research effort, and collaboration within the sector and with business. These discussions will be informed by the results of the first round of the Excellence in Research for Australia (ERA) initiative, which will help universities identify their research strengths and establish goals for strategic investment in other areas…" (CGOA, 2010i).

The model compact agreement, issued by the federal government in October 2010, asks universities to make comments or commitments on its plans and priorities for contributing to innovation and economic growth, including how the university proposes to use Commonwealth funding to: collaborate or partner with industry; contribute to knowledge transfer; or improve commercialization outcomes.

7.6 Summary Findings

Between 1945 and the early 1980s the Australian manufacturing sector performed very little of its own R&D and placed considerable reliance on imported technology and there was little exposure of the manufacturing sector to international competition. On the other hand, the commodity sectors, including forestry, agriculture, and mining, were more exposed to international competition and were more concerned with improving their R&D performance.

Beginning in the early 1980s U-B collaboration became an increasing concern for Australian governments and encouraging U-B collaboration moved on to their innovation policy agendas. One important driver for this development in Australia was the massive change in the structure of Australia's higher education system in the late 1980s (the "Dawkins Revolution").

Australian governments have been increasingly strong advocates for greater U-B collaboration since the 1980s. They have instituted formal and annual reporting systems on U-B collaboration and, in publishing the results, are including international benchmarks. The Australian federal government is deepening its role as an enabler of U-B collaboration, including through an A$ 250.7 million investment (over five years starting in 2008) in a new tranche of intermediary organizations (six manufacturing centres and six innovation centres).

The Australia federal and state level governments have employing a range of research funding institutions and instruments to encourage U-B collaboration and, in this, they are acting no differently than governments in the UK, the US or Canada. Beyond conditions attached to research grants, the Australian federal government have: introduced a Joint Research Engagement Program (which de-links block grants for university research from a university's success in obtaining competitive research funding from public sources); and provided A$ 244 million in funding (over five years) for a new organization, Commercialisation Australia, to deliver programs to support the commercialization of research.

The Australian federal government is an active rule-maker for improving the environment for U-B collaboration. Its 2009 *Powering Ideas* innovation agenda highlights its interest in supporting greater clarity and certainty for the management of intellectual property in university settings (recent legal proceedings may prompt the federal government to address more directly the issue of the best models for university IP policies and processes in Australia).

The federal government has legislative authority for the regulation of clinical trials of human therapeutic products. Not in all cases, but quite often, such trials involve university-business collaboration. The federal government has commissioned a review of the Australian clinical trails system to determine how it might best proceed to achieve a number of broad objectives. The decisions it takes will have an important influence on Australian U-B research collaboration in the life sciences sector.

Australian federal and state level governments tread carefully in areas relating to university governance. Nonetheless, the Australian federal government is continuing to exercise indirect influence through the negotiation of Mission Based Compacts with universities (e.g., seeking to align university priorities with its own innovation policy agenda and priorities).

8.0 Conclusions and Lessons for Canada

Canadian governments are interested in encouraging U-B collaboration, particularly research collaboration, in order to: help differentiate and distinguish the Canadian knowledge economy from those of other jurisdictions; extract greater economic and social value from public investments in education and research; open up new opportunities for universities to equip students with skills and knowledge; bring the results of university research to their citizens more quickly than might otherwise the case; and strengthen the productivity of Canadian business and social sectors.

How can Canadian governments strengthen their role and effectiveness in encouraging university-business research collaboration? To help answer this question, this report has:

- reviewed findings from the research literature on motivations for, barriers to, and determinants of U-B collaboration;

- taken into consideration how U-B collaboration is measured and Canada's international ranking on U-B collaboration; and,

- examined how governments are encouraging U-B collaboration in three reference countries – the US, the UK and Australia.

Findings from the research literature

Universities and businesses have different motivations for collaborating. A number of surveys find that businesses do not rank increasing their profitability as their top motivation for collaborating with universities. This is deserving of further research to better understand, given that other surveys find that businesses perceive the "long term orientation" of university research as a significant barrier to collaboration. This report suggests that business concern over the long-term orientation of university research may not only be misplaced but may run counter to their own self-interest. U-B collaboration that involves long time-frames (although not indefinite time frames) may in fact be a healthy tonic for businesses through re-dressing the balance between a short-term focus on quarter-to-quarter market expectations and seeking to create long-term value for shareholders.

Business determinants for entering into research collaborations with universities have been the subject of extensive research. Major findings include:

- **large firms are more likely to collaborate with universities than are small firms.** However, there is good reason for policy makers to focus on encouraging collaboration between smaller firms and universities. Firm size has generally not been found to be a robust predictor for innovation. In fact, while large firms do spend more on R&D than smaller firms, due to their size and greater profits, they may not be intrinsically more innovative. Indeed, small firms are found be more innovative per dollar of R&D;

- **U-B collaboration is more likely to occur in some economic sectors than others.** The extent of U-B collaboration within any jurisdiction reflects the research intensity of different economic sectors. Cross-national differences in U-B collaboration may reflect differences in the structure of national economies. The policy implication is that rather than seeking to encourage U-B research collaboration across all economic sectors, governments should target and focus their support where there is business interest and market opportunity. However, this should not come at the expense of supporting basic and fundamental research in the higher education sector;

- **firms tend to collaborate with universities that are nearest to them.** The policy implication is that sub-central governments (e.g., provincial and municipal governments in Canada) have as great a role to play in encouraging U-B collaboration as do national governments;

- **Reports on the death of the linear model of innovation, where universities push out inventions and knowledge which are then commercialized by businesses, have been exaggerated**. The linear model implies there is a one way flow of knowledge: universities are the location for basic research which is then translated through applied research to commercialization and application in the marketplace. This linear model has fallen out of favour over recent decades. Other perspectives on innovation have been advanced, including those based on "ecosystem" and network models of innovation processes. Yet linear models remain prominent within government policy statements. It is likely that the most effective public policies to improve business innovation and encourage U-B collaboration in the future will draw insight from both traditional and new ways of thinking about innovation;

- **multinational companies take the presence of, and access to, high quality universities into full account when allocating their global R&D investments.** The policy implication is that encouraging foreign investment by research intensive multinational companies requires continued public investment in internationally competitive and research intensive universities; and,

- **in the specific case of tax-based incentives for business R&D, little is known about their impact on the level of business funding of university research.** However, tailoring R&D tax credits to encourage U-B research collaboration involves some risk that it will incent firms to substitute spending on internal R&D for external R&D rather than increasing their total investment in R&D and allocating them between internal and external performers according to what makes the most business sense.

Measuring U-B collaboration and Canada's international ranking

Measuring U-B collaboration currently relies on a fairly narrow range of indicators related to: research funding; features of the scientific literature (bibliometrics); technology transfer and commercialization activity; and data from various surveys of innovation and business opinion. Indicators in each of these areas have various strengths and limitations. In summary:

- **funding indicators.** These indicators are important, but should not lead us to believe that we know what the "optimal" level of business investment in university research may be and, if only by implication, what the "optimal" level of U-B collaboration in research may be. A related point is that market forces do not always function to define optimality of business investment in university research. Some informed observers believe that it is public investment in university research that drives the level of private investment in university research, even though this has not yet proven to be the case in Canada.

- **bibliometric indicators.** The number of university-industry co-authored (UIC) science and technology publications is increasing internationally, in part driven by increasing UIC publication rates in China. Canadian UIC publications increased between1980 and through to 2005 to reach the rates achieved in the US over recent years;

- **technology transfer and commercialization indicators.** These indicators are challenging to construct, are subject to wide interpretation and, in any case, their relevance as proxy indicators of U-B collaboration (as opposed to technology transfer activity levels) is open to debate. Based on 2004 data assembled by two experts, the US leads the UK and other EU countries by indicators of commercial potential (e.g., patent applications and patent grants per dollar of research expenditure), while universities within the UK and other EU countries lead by indicators of commercial application (e.g. licence executed and university start-up companies formed per dollar of research expenditure). US universities appear to lead all jurisdictions by licence revenues received as a percentage of total university research expenditures. Canadian and Australian universities present a mixed picture relative to other jurisdictions; and,

- **results from surveys of business opinion.** There are various surveys on business opinion on the strength of linkages between universities and business. Canada has moved up in the rankings for U-B research collaboration within the World Economic Forum's Executive Opinion survey results over the past decade. It has moved from 9th place position to 7th place over the last two years. The IMD survey of executive opinion on whether "knowledge transfer" between companies and universities is "highly developed" or "lacking" in their countries has also assigned Canada an increasing rank over the past three years: Canada has increased its ranking from 10th place in 2008 to 8th place in 2010 (although it ranked in 6th place in 2001).

This report finds that, on balance, indicators of U-B research collaboration suggest that Canada is not significantly lagging other jurisdictions. But Canada is not a world leader in U-B research collaboration. Canadian businesses are investing more in university research (as a share of GDP) than are businesses in other jurisdictions and by a considerable margin. However, there are important technical considerations relating to the international comparability of the available data. In addition, it remains for further research how much of the Canadian lead may be attributed to a few research projects conducted by a few companies.

U-B Collaboration and Productivity

The empirical research base on the relationship between U-B research collaboration and productivity performance is still being built. U-B research collaboration appears to make a positive contribution to: firm-level productivity performance (although one can always find individual cases where this may not be so); possibly also to academic research productivity; and, if only by implication, to economy-wide productivity performance (although by how much, even if it were measurable, is completely unknown).

The policy experience with encouraging U-B collaboration in Canada and three reference countries – the US, the UK and Australia

This report has described the public policy experience in encouraging U-B collaboration in Canada and three reference countries – the US, the UK and Australia. In general, governments in all four countries are deepening their role as advocates, enablers, funders, and rule-makers for U-B collaboration (see summary table included within the Executive Summary of this report). The main findings to be drawn from the experience of the three reference countries are:

- **The United States.** Some informed UK observers, including within the Higher Education Funding Council for England, have expressed reservations on what, if anything, the US has to teach other countries with respect to knowledge transfer between US universities and business. Informed US observers, including from the US National Academies of Sciences, have also expressed concern with the US "knowledge exchange" performance. This report does not share such pessimistic viewpoints. Notwithstanding the rise of other "knowledge based economies" around the world, the US has successfully branded itself on the world stage as having distinctive knowledge advantages across a range of areas. The extent of U-B collaboration, and US federal, state and local measures taken to encourage U-B collaboration, are not the only or even main reasons for this achievement but they have played a supporting role.

  Of course, branding is one thing and underlying substance is another. But it would be a brave soul who would suggest that the US is no longer a global leader across a wide range of scientific and technological fields and based partly, although not entirely, on U-B (and, of course, government) research collaboration. A 2008 assessment of US S&T global leadership commissioned by the US Department of Defense and conducted by the RAND Corporation found that the US: accounts for 40 percent of total world R&D spending; 38 percent of patented new technology inventions within the OECD; employs 37 percent of OECD researchers; produces 35 percent, 49 percent, and 63 percent, respectively, of total world publications, citations, and highly cited publications; employs 70 percent of the world's Nobel Prize winners and 66 percent of its most-cited individuals, and remains the home of a majority of the world's top research universities (Galama and Hosek, 2008). The European Commission reported in 2003 that: "The US innovation performance reflects an innovation system characterised by good levels of tertiary education, good linkages between the public science system and the private sector, strong private investment in R&D and a successful commercialisation of technological knowledge." (EC, 2011: 5). The US is not taking its world-leading position for granted. It is improving its data collection on innovation and U-B collaboration, and undertaking fundamental reviews of its innovation and U-B collaboration governance structure and performance.

- **The United Kingdom.** Perhaps no other OECD government has been a louder advocate for U-B collaboration than has the UK Government. In 2003 the UK Treasury commissioned Richard Lambert, now Director General of the Confederation of British Industry and Chancellor of the University of Warwick, to conduct a review of business-university collaboration in the UK. The recommendations of the Lambert Review, while controversial in some quarters, essentially provided a national U-B collaboration plan for UK governments, businesses and universities over the seven years that followed. It may be that the UK Government has renewed aspects of this plan through issuing, in November 2010, a *Blueprint for Technology*.

- **Australia**. Australian governments have instituted formal and annual reporting systems on U-B collaboration. The Australian federal government has begun to systematically and annually report on Australia U-B collaboration performance against available international benchmarks. The Australian federal government is deepening its role as an enabler of U-B collaboration, including through an A$ 250.7 million investment in manufacturing and innovation centres that sit between universities and business. It has also invested A$ $244 million (over the five years starting in FY 2010) in a new organization, Commercialisation Australia, that centralizes public funding for research commercialization activities (often involving universities) and delivers it to businesses through a formal program structure.

Lessons for Canada and Policy Recommendations

In any area of public policy, drawing and applying "policy lessons" from other countries to one's own country is a notoriously difficult and hazardous task. Seldom if ever can specific measures taken, or institutional forms created, be transferred directly from one jurisdiction to another without substantial and substantive modification. This report's review of the policy experience with encouraging U-B collaboration in Canada and the three reference countries shows that national circumstances, including the structure and performance of innovation and educational systems, influences the choice of policy instruments and the design and implementation of specific measures. On this same point, it is useful to recall the words of the Honourable Donald S. MacDonald, in his Chairman's introduction to the 1985 report of the *Royal Commission the Economic Union and Development Prospects for Canada*:

> "…Canadians have too often fallen into the habit of accepting a foreign lead or adopting a foreign opinion before fully thinking through what is appropriate for *us* in *our* circumstances." (GOC, 1985: xii). [Italics contained in source document]

This report finds that Canada can and should improve its U-B collaboration performance in research and possibly other areas. It should do so not because other countries are doing so (although that is one consideration) but because it is in its own self-interest. For instance:

- differentiating (and not only building) "knowledge economies" is a policy priority for governments across all major economies. Encouraging U-B collaboration is not the only or even the most important way for Canadian governments to differentiate and distinguish Canada's knowledge economy from those of others, but it can contribute to that objective. For instance, whether Canadian governments view the economic world as increasingly flat (Friedman, 2005) or, alternatively, increasingly spiky (Florida, 2005), measures to encourage U-B collaboration are one way for them to help create location advantages for attracting and retaining internationally mobile capital and highly qualified people.

- governments in other national jurisdictions, including the US, the UK and Australia, are investing heavily in their higher education systems and in programs to better connect their universities with their domestic industries. Canada is already a world leader in making public investment in education, including higher education. In this leadership position, it has an even greater incentive than other countries to: sustain these investments, even in the face of slow economic growth and competing economic priorities (e.g. health care); and continually seek new ways to derive greater social and economic value from these investments. Encouraging U-B collaboration is not only way to achieve this latter objective, but all the evidence points to U-B collaboration as an important means to that end; and,

- meeting the economic, social and environmental challenges that we know are before us, to say nothing about those we are not yet aware of, requires that the knowledge created within universities be moved to application in the world more quickly than ever before. Canadian governments should encourage U-B collaboration as one means to help achieve this result and in ways that are tailored to Canadian economic, social and environmental circumstances. At the same time,

> it is also one means to strengthen Canada's voice on the world stage and, to use Joseph Stiglitz's words, recognize that knowledge is a global public good.

In an international context, indicators of U-B research collaboration suggest that Canada is not significantly lagging other jurisdictions. But neither is Canada a world leader. Large public investments in Canadian university research are not markedly drawing out private investment and, if only by implication, encouraging U-B research collaboration. Canadian governments can strengthen their role and effectiveness as advocates, enablers, funders, and rule-makers for U-B collaboration. Each of these areas contains significant challenges but also significant opportunities.

Canadian Governments as Advocates for U-B collaboration

What governments decide to measure and report to citizens matters to the development of public policy, the exercise of national influence on the world stage, and is a critical underpinning of all advocacy activity. Government agencies in Australia, the UK and the US are increasing their effort to better understand and report on U-B collaboration. Canada has been a follower rather than a leader in this area.

Across all four jurisdictions considered in this report, informal interactions between business and university sectors are found to be as important as formal interactions. Harnessing the interest and the influence of individual Canadian business and university leaders, and university faculty and researchers, will be critical to raising the public profile and promoting greater understanding of why greater U-B collaboration matters to deriving greater economic and social value for large public investments in research and education.

Canada has no permanent, national, and "peak-level" forum that brings together university and business leaders as do the US, the UK, and Australia. Just because other countries have such forums does not mean that Canada should have one. Nonetheless, should the case be marshalled for a new U-B forum, the lessons from other jurisdictions are: the forum's mandate should be wider than just U-B advocacy; and that the forum should be initiated, funded and supported by universities and businesses themselves. In 2008, Australia's Business, Industry Higher Education Collaboration Council, created and funded by the Australian Commonwealth Government, considered that its job was done when the end of government funding came into sight. On the other hand, the Business Higher Education Forum in the US, the Council for Industry and Higher Education in the UK, and the Business-Higher Education Roundtable in Australia, are long established forums created and funded by universities and businesses. They continue to be valued by their members.

Main Recommendation

The federal government should issue a clear statement of its objectives and expectations for the future of U-B research collaboration in Canada that can both inspire and serve as a touchstone for measuring progress (the Government of

Québec is already moving in this advocacy direction through setting out, within its 2010 innovation policy statement, its target for U-B research collaboration in Québec). However, the federal government should resist the temptation to take a leadership role in establishing or funding a new forum that brings together university and business leaders. Even though such forums exist today in the US, the UK and Australia, and have existed in Canada in the past, Canadian university and business leaders themselves must decide if such a forum is required and what useful functions it could serve.

Canadian Governments as Enablers of U-B Collaboration

Canadian governments are enablers of U-B collaboration and primarily through providing financial and other forms of support for the establishment and operation of a growing number of intermediary organizations. This report finds that, largely due to federal and provincial government support, Canadian intermediary organizations are today characterized by: strong national and regional coverage; considerable sectoral coverage (both technology and economic sectors) although further research is required to see what important gaps may remain; balanced and strong representation from both university and business sectors; and, most encouragingly of all, are increasingly connected with one another rather than operating in isolation from one another. This report also finds that Canadian governments can be stronger enablers of U-B collaboration in the future through:

- encouraging intermediary organizations to intensify effort to look beyond regional and national boundaries. As of yet, no Canadian intermediary organization can claim to have achieved the reach of the US Semiconductor Research Corporation, a US intermediary organization which has formal research funding connections with over 130 universities in the US and abroad; and,

- stepping back to take a system-wide perspective on the role and effectiveness of intermediary organizations. More generally, governments should think more deeply about why intermediary organizations are required in the first place. Is their increasing prominence a positive response to growing complexity in innovation processes (a suggestion supported by the growing presence of equivalent organizations in other jurisdictions) or are they perhaps a warning sign of fundamental weaknesses in Canadian business organization and business culture?

Main Recommendation

The federal government should review the role and effectiveness of intermediary organizations the sit between universities and business and which are increasingly important conduits for federal funding of U-B research and related commercialization activities. The review should address at least three questions: (1) are there significant gaps in sectoral or technological coverage or in the type of

intermediation activities and services offered?; (2) should longer-term financial support be provided to some of these organizations for some portion of their operational expenses?; and (3) are they sufficiently transparent and accountable conduits for helping to assemble and flow public research dollars to U-B research projects?

Canadian Governments as Funders of U-B collaboration

There is no shortage of federal and provincial R&D funding programs which are geared to encouraging U-B collaboration. At the federal level, Canada has four major federal research agencies, four regional development agencies, and a diverse range of government line departments, all of which have programs for funding U-B research collaboration. This report estimates that at least C$ 370 million is being spent annually on federal programs that have encouraging U-B collaboration as a major objective. There is little evidence that this funding is going to waste. However, as in other areas of government support for R&D, it is extraordinarily difficult to attribute outputs or outcomes (as measured by any given indicator or group of indicators) to any specific government policy measure or program.
There are many improvements that can and should be made to existing funding measures and processes for encouraging U-B collaboration. In particular:

- the Canadian federal government has placed an emphasis on seeking "private sector input" at the initial resource allocation stage for some research funding programs. Greater attention might now be paid to increasing private sector involvement during the actual research process itself;

- the US and a number of other foreign jurisdictions have created R&D tax credits specifically designed to encourage U-B collaboration (as have the governments of Ontario and Québec). Canadian governments should conduct a review of the effectiveness of such credits (the European Commission's Expert Group on the Impacts of R&D Tax Credits has recommended that the European Commission undertake a joint evaluation of tax credits for encouraging U-B collaboration found in a several EU member countries);

- there is an opportunity for Canadian governments to embrace an open and international vision for the future of Canadian voucher programs that subsidize SMEs in the purchase of commercialization services and expertise from the higher education sector. Today only three out of 25 voucher schemes within the European Union are open for a limited degree international co-operation. By designing voucher programs that have regional, national and international reach and openness, Canadian governments can encourage Canadian companies (especially SMEs) to look beyond local borders for knowledge and business opportunities. Making vouchers available to foreign companies could bring them (and foreign investors) to look more closely at opportunities to work with Canadian universities;

- for decades Canadian governments have been asked to “lever” public procurement to achieve an ever expanding number of social and economic objectives. Most recently, the federal government has introduced a new defence procurement incentive to encourage the formation of university-business consortiums to conduct defence related research. This initiative follows in the path being taken by other governments around the world. Both civil and defence procurement programs in other countries are also incorporating requirements for suppliers to collaborate with institutions of higher education. Governments, businesses and universities in other countries have taken note of this development. Canadian governments should consider making funding available to Canadian universities and business to support their involvement in the growing number of overseas procurement opportunities; and,

- Are there more effective and efficient institutional arrangements at the federal level for delivering public support for U-B research collaboration and related commercialization activities? The time may have come for at the least the federal government to consider institutional options for the more effective coordination and delivery of the diverse range of programs for funding U-B research collaboration and related commercialization activities.

Main Recommendation

The federal government should examine the option of moving lead responsibility for many existing funding programs for U-B research collaboration and related commercialization activities to a single organization operating at arms-length from government. Such an organization could pursue tangible and unambiguous objectives that are grounded on real market circumstances and opportunities. It does not have to be “business-led” but must have business and university participation and support.

- This report examined whether the tax system or direct program spending should be relied upon to encourage U-B research collaboration. This report suggests that tax incentives are most effective as framework policies that provide general support for specific activities across the entire economy and that do not discriminate between firms, industries or technologies. At least arguably, direct program spending is most effective where market failures are large and concentrated in localized situations or the target group can be narrowly defined.

Main Recommendations

The federal government should continue to provide direct funding to encourage U-B research collaboration at least up to current levels (estimated in this report as being over C$ 370 million annually) rather than enriching the existing Scientific Research and Experiment Development (SR&ED) tax credit specifically to incent businesses to allocate a higher proportion of their R&D spending to university research.

Canadian Governments as Rule-makers for U-B Collaboration

There are a number of areas of rule-making that influence the environment for U-B collaboration and in which, by and large, Canadian governments have a good track record. But this report also finds:

- there is growing recognition within Canadian federal and provincial governments that Intellectual Property (IP) processes are as important as IP policies for U-B research collaboration. At the federal government level, the Natural Sciences and Engineering Research Council of Canada has taken action to provide universities with greater “flexibility” on how they treat IP generated from its research grant awards – although whether this policy direction is the right one remains a subject for further study. Diversity and “flexibility” in university IP arrangements are seen by some as desirable, but others believe it may be an impediment to U-B collaboration;

- increasing the transparency of the foreign investment review process (but not engaging in an ultimately fruitless exercise to better define what investments are of “net-benefit” to Canada) may be desirable for many public policy reasons. One reason is that greater transparency will help ensure that the benefits of foreign investment regime in terms of encouraging U-B collaboration will receive a higher profile than is currently the case; and,

- existing systems for the regulation of research are generally not perceived as major obstacles to U-B research collaboration in Canada today, but Canadian governments must continue to make investments in this area of rule-making even in the face of an always uncertain scientific and technological future. How governments choose to regulate research in many frontier technology areas may be expected to impact – either positively or negatively – on U-B collaboration. Government rule-making in this area should be characterized by foresight, rather than seeking to patch up problems after the technological horse has left the laboratory.

Main Recommendation

The federal government should lead a structured national discussion involving businesses, universities, and provincial governments on how to improve processes for the negotiation and management of intellectual property (IP) within university settings.

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Annex I
European Commission initiatives and U-B Research Collaboration

Over the past two decades, UK Government advocacy of U-B collaboration in research and other areas has been extended through its membership in the EU and, in turn, the European Commission's own increasing advocacy of U-B collaboration has complemented the UK government's policy directions. Examples of European Commission (EC) statements relevant to U-B collaboration include:

- **European Commission Communications on: *Delivering on the modernization agenda for universities* (2006); and *A new partnership for the modernization of universities* (2009).** Both these communications address a wide range of challenges facing universities within EU member states (including the need to achieve the Bologna educational reforms by 2010 in all EU countries[166]), and both highlight opportunities to encourage greater U-B collaboration. The 2006 communication calls for incentives for structured partnerships with the business community although it was vague as to who should provide and pay for those incentives:

> "Structured partnerships with the business community (including SMEs) bring opportunities for universities to improve the sharing of research results, intellectual property rights, patents and licenses (for example through on-campus start-ups or the creation of science parks).They can also increase the relevance of education and training programmes through placements of students and researchers in business, and can improve the career prospects of researchers at all stages of their career by adding entrepreneurial skills to scientific expertise. Links with business can bring additional funding, for example to expand research capacity or to provide retraining courses, and will enhance the impact of university-based research on SMEs and regional innovation.
>
> To secure these benefits, most universities will need external support to make the necessary organisational changes and build up entrepreneurial attitudes and management skills. This can be achieved by creating local "clusters for knowledge creation and transfer" or business liaison, joint research or knowledge transfer offices serving as an interface with local/regional economic operators. This also implies that development of entrepreneurial, management and innovation skills should become an

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[166] The 1999 Bologna Declaration sets out a vision for achieving by 2010 an internationally competitive and attractive European Higher Education Area (EHA) that will: facilitate mobility of students, graduates and higher education staff; prepare students for their future careers and for life as active citizens in democratic societies, support their personal development; and offer broad access to high-quality higher education, based on democratic principles and academic freedom. The EHA was launched in March 2010 by Ministers responsible for higher education in the 37 European countries participating in the Bologna process.

> integral part of graduate education, research training and lifelong learning strategies for university staff." (COM(2006) 208 final:6).

The European Commission's 2009 Communication opens by clarifying who will pay for the "incentives for structured partnerships":

> "A key element within the agenda set out in 2006 was that universities should develop structured partnerships with the world of enterprise in order to "become significant players in the economy, able to respond better and faster to the demands of the market and to develop partnerships which harness scientific and technological knowledge". The Communication suggested that enterprises could help universities to reshape curricula, governance structures and contribute to funding." (COM(2009) 158 final:2)

It then goes on to review progress under the European Commission sponsored University-Business Forum and concludes with the advocacy statement:

> "The right time for a strong new push for university-business cooperation is now. In times of economic downturn, when graduates face greater difficulty to find jobs and enterprises are subjected to higher competitive pressure, the economic and social value-added of university business collaboration should make it even more a priority." COM(2009) 158 final:11)

- **European Commission Communication on Better Careers and More Mobility (2008).** This communication proposes a new partnership to align and focus the efforts of individual Member States through a series of "joint priority actions" that should make the EU a more attractive place for researchers, and allow researchers to be more mobile between countries, institutions, and between the academic and private sectors. The priority actions included: development and support consistent "national skills agendas" to ensure that researchers are equipped with the necessary skills to contribute fully to a knowledge-based economy and society throughout their careers; and ensure better links between academia and industry by supporting the placement of researchers in industry during their training and promoting industry financing of PhDs and involvement in curriculum development. (COM(2008)317 final).

- **European Commission Communication on *Improving knowledge transfer between research institutions and industry across Europe: embracing open innovation* (2007).** This communication "sets out ideas on how Member States and the Community can act together, in a mutually reinforcing way, to overcome some of the existing obstacles, in particular in terms of promoting the trans-national dimension of knowledge transfer." It is accompanied by a Commission Staff paper on "voluntary guidelines for universities and other research institutions to improve their links with industry across Europe." (COM(2007) 182 final).

- **European Commission Recommendation on *The management of intellectual property in knowledge transfer activities and Code of Practice for universities and other public research organizations* (2008).** Te recommendation and code of practice is based on the Commission's view that:

  > "Member States have taken a number of initiatives in recent years to facilitate knowledge transfer between PROs [Public Research Organizations] and the private sector such as legislative changes and the development of guidelines or model contracts, but these measures were often designed from a purely national perspective. This approach did not address the discrepancies between national systems, and hampered trans-national knowledge transfer." (EC IP/08/555, Brussels, 10 April 2008).

- **European Commission Communication on *EUROPE 2020 A strategy for smart, sustainable and inclusive growth* (2010).** In June of 2010 the European Council formally adopted "Europe 2020", a new strategy for "jobs and smart, sustainable and inclusive growth." (EUCO 13/10). The strategy, based on the EC's March 2010 communication to the Council, includes a variety of "headline targets" (e.g., improving the conditions for research and development, in particular with the aim of raising combined public and private investment levels in this sector to 3% of GDP and with the EC Commission to "elaborate an indicator reflecting R&D and innovation intensity"). The EC's Communication on Europe 2020 states that, as part of the new strategy, the EU Commission will work to promote knowledge partnerships and strengthen links between education, business, research and innovation and, at the national level, Members States will need:

  > "To reform national (and regional) R&D and innovation systems to foster excellence and smart specialisation, reinforce cooperation between universities, research and business, implement joint programming and enhance cross-border co-operation in areas with EU value added and adjust national funding procedures accordingly, to ensure the diffusion of technology across the EU territory…" (COM(2010) 2020).

Annex II

"Open Innovation" and U-B Research Collaboration

A number of OECD studies and other economic policy think tank reports (as well as a number of OECD government innovation strategies) suggest that R&D internationalization is being accompanied by new models of "open innovation" in which local U-B research collaboration is presented as one important feature.[167] The OECD reports that:

> "Confronted with increasing global competition and rising research and development (R&D) costs, companies can no longer survive on their own R&D efforts but look for new, more open, modes of innovation. Companies' innovation activities are increasingly international, and they are embracing "open innovation" – collaborating with external partners, whether suppliers, customers or universities, to keep ahead of the game and get new products or services to market before their competitors. At the same time, innovation is being "democratised" as users of products and services, both firms and individual consumers, increasingly become involved in innovation themselves." (OECD, 2008: 1).

There is anecdotal evidence suggesting that U-B collaborations are important to "open innovation" business strategies.[168] But we also have the example of Google in China that appears to test the limits of open innovation as a business strategy. In 2005, Google announced it would establish an R&D center in China and thereby make a strong commitment to attracting and developing Chinese talent and partner with local universities and institutes. (Google, 2005). Then in early 2010 Google announced that it would consider shutting down Google.cn due to a dispute with the Chinese government over whether the company could operate an unfiltered search engine. David Drummond

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[167] Open innovation has been defined as the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively. It assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as they look to advance their technology. (Chesbrough, 2003)

[168] Two among many examples are the bio-pharmaceutical companies Genzyme and Norvatis. Genzyme is now nearing completion of a US$ 100 million biotechnology R&D facility at Beijing Zhongguancun Life Science Park (located adjacent to Peking University and Tsinghau University) in China. According to Gensyme: "Our approach is designed to locate us near important markets, give us access to the widest possible scientific talent pool and position us to work closely with regional regulatory authorities, all over the world." (Gensyme Corporate Brochure: 2010). The Head of Economic Affairs for Novartis has said that "open innovation is standard practice at Novartis." (Mumenthaler, 2008:16). In November of 2009, Norvartis announced a five-year US$ 1 billion investment to increase its R&D activities in China, including expanding the Novartis Institute for BioMedical Research (NIBR) which is located adjacent to Shanghai's emerging cluster of academic, biotech and pharmaceutical research institutions (Norvartis, 2009).

(Google's Senior Vice President of Corporate Development and Chief Legal Officer) said in March 2010 that Google would stop censoring its search services on google.cn but also that:

> "In terms of Google's wider business operations, we intend to continue R&D work in China and also to maintain a sales presence there, though the size of the sales team will obviously be partially dependent on the ability of mainland Chinese users to access Google.com.hk. **Finally, we would like to make clear that all these decisions have been driven and implemented by our executives in the United States, and that none of our employees in China can, or should, be held responsible for them.**" (Drummond, 2009: Google Blog).[169] [emphasis added].

Google's decision and its possible motivations are of interest here for two reasons. First, they run contrary to notions of open innovation that suggest that tasks previously kept close to head office, and often requiring high degrees of trust, reliability and education, are always being "democratised" (to use the OECD's word). Second, Google's decision to maintain its R&D presence in China may have been influenced at least as much by the actions of its competitor, Microsoft, as by any desire to "access local knowledge" including through collaborations with universities and local firms. Even as Google was considering shutting down Google.cn, Microsoft was announcing its plans to expand its R&D centre in Shanghai and completing construction of the Microsoft Asia-Pacific R&D headquarters in Beijing.

Perhaps "open innovation" as a business strategy, including its U-B collaboration elements, can only apply within a bounded set of political, social, and economic conditions. It remains to be fully tested against the considerable weight of business and economic incentives for seeking to capture much while sharing only when it is in the interest of a company and its shareholders to do so.

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[169] In early July 2010 the Government of China renewed the Internet Content Provider (ICP) operating license of Beijing Guxiang Information Technology Co. Ltd., operator of Google's China website. According to China's government news agency, Guxiang pledged to abide by Chinese law, ensure the company provides no illegal content, and also accepted that all content it provides is subject to supervision of government regulators.

Annex III

Venture Capital and U-B Research Collaboration

One perspective on government venture capital programs and policies may be that they have very little to do with encouraging U-B collaboration although of course they are important to broader processes for the commercialization of university research. But an alternative perspective is that the relationship between universities and capital markets, particularly venture capital markets, is a highly significant feature of U-B collaboration (if not directly than at least as an important contextual feature of the institutional environment for U-B collaboration) and extension so are government VC programs and policies.

Four examples among many Canadian government venture capital programs and organizations that focus on the university sector are:

- The Québec-based iNovia Capital venture capital organization was originally formed as a seed fund dedicated to commercializing research at McGill University, University of Sherbrooke and Bishop's University. MSBi Valorisation (MSBiV) was spun-off in 2003 from iNovia as iNovia broadened its own venture capital financings beyond Québec based universities. MSBiV is one of four sociétés de valorisation des résultats de la recherche universitaire du Québec (SVUs). MSBiV is not strictly a venture capital organization (although it does invest through convertible debt instruments in university start-up firms). From its inception in 2003 up to March 2008, MSBiV benefited from a loan provided by the federal government's Canada Economic Development for Québec Regions (CED-Q). Since 2006, MSBiV has benefited from financial support from the Government of Québec's Ministère du Développement économique, de l'Innovation et de l'Exportation.

- The Government of Nova Scotia's Crown Corporation, Innovacorp, has some venture capital funding functions that often centre on (but are not limited to) early stage companies seeking to commercialize research from Nova Scotia universities. Innovacorp manages the Nova Scotia First Fund (NSFF). The fund's investment strategy targets emerging venture-grade technology companies with high growth potential and attractive risk-return prospects. The fund has capacity to invest in new opportunities, with capital commitments of over C$ 40 million. Key industries include: clean technology, information technology, and life sciences. In addition, and although not a venture capital investment instrument, Innovacorp's Early Stage Commercialization Fund supports projects demonstrating readiness to advance a technology that has achieved, or is close to achieving, a prototype/proof-of-concept stage and is approaching market readiness with a possibility of attracting industry partners and/or investment.

- The Government of New Brunswick's Innovation Foundation was established in 2003 with a mandate to strengthen the innovation capacity of New Brunswick by making investments in applied research and new growth-oriented businesses. The Innovation Foundation operates a venture capital fund, including (but not limited to) for the early-stage support for commercialization of university research.

- The federal government's Business Development Bank (BDC) is a key player in the venture capital (VC) sector with C$ 735 million in commitments, comprised of direct and indirect (through VC funds) investments. It has invested C$ 1.2 billion in VC in technology firms since 2000 and reports that: "42% of BDC investees originated in the research or university labs." (BDC, 2010a: 84).

Little research has been undertaken on the form and scope of linkages between public and private venture capital programs and instruments and Canada's universities and researchers. It is known that of between 400 and 600 VC deals are executed in Canada annually, some 55 percent represent early stage deals (in contrast to US where the VC industry focuses on "later stage" deals). This may suggest that Canadian universities (some of whom themselves are VC investors) have strong research linkages to new companies (not merely university start-up companies) that are financed by the VC industry (both public and private). This suggestion finds some support through just a cursory glance at the top ten (disclosed) venture capital deals in Canada in 2009. At least six of the top ten VC deals in 2009 involved companies with significant connections to research at Canadian universities and at least three of these six deals involved government venture capital organizations (see Table 19 next page).

Table 19
Six out of the top ten (disclosed) Venture Capital Deals in Canada in 2009 with strong linkages to university research and/or government VC involvement

Company	Sector	Announced Financing in 2009 (C$ M)	Strong Company Linkage to University Research?	Government VC Involvement?
TOPIGEN Pharmaceutical Inc., Montreal, Québec (company acquired by the Australian pharmaceuticals company Pharmaxis in early 2010)	Pharma	26.0	Yes. With the University of Montreal and McGill University. In addition, Topigen acquired the McGill University spin off-company, Anagenis Inc., in 2004.	BDC
Enobia Pharma Inc., Montreal, Québec	Pharma	54.2	Yes. With McGill University's Deparatment of Anatomy and Cell Biology on biomineralization (work funded in part by the Canadian Institutes of Health Research).	Investments for Solidarity Fund QFL (not strictly a government VC fund)
OneChip Photonics Inc., Ottawa, Ontario	Photonics	19.5	Yes. With the University of Ottawa and McMaster University. Received support from Ontario Government's Centre of Excellence Collaboration Research Program.	BDC
Allostera Pharma Inc., Montreal, Québec	Pharma	17 M	Yes. The company's 2005 incorporation was managed by Gestion Univalor, L.P., an entity whose mission is the transfer to industry of intellectual properties from the Université de Montréal, its affiliated schools and most of its affiliated hospitals (and which lists the Qeubec and federal governments as its partners). Research was funded from 2002 to 2009 under grants given by Univalor and the Canadian Institutes of Health Research Proof-of-Principal Program directly to a University of Montreal laboratory, debt from the "Centre québécois de valorisation des biotechnologies" (CQVB), convertible debt from Univalor, MSBi Valorisation (a government supported company dedicated to pre-seed technology-based investments), Fonds Bio-Innovation s.e.c., and angel investors, and a grant from the Québec Government.	BDC, le Fonds Bio-Innovation s.e.c. (a mixed private-public fund)
ResVerlogiX, Calgary, Alberta	Pharma	24.3	Yes. Research collaboration with the Division of Cardiology at the Research Institute of the McGill University Health Centre.	No.
General Fusion Inc., Burnaby, BC.	Energy	23.5	No. (although has research collaboration with US Los Alomos National Laboratories and receives support from the federal Sustainable Development Technology Canada and NRC IRAP)	No.

Source: Top Ten Deals (disclosed) identified by Thomson Reuters and the Canadian Venture Capital Association in their publication *Canada's Venture Capital Industry in 2009*. Linkages to university research and identified government venture capital involvement identified by the author based on a scan of publicly available information on corporate and investor service web sites.

Annex IV

Sources and Notes for Table 8 (page 89 of this report) Canadian Federal Government Funding Programs with Encouraging U-B Research Collaboration as a Primary Objective: Estimates of Annual Expenditures

Notes	Federal Funding Programs	Estimated Annual Funding (C$ M)
	Individual Federal Research Council Programs	
1	NSERC	181.0
2	CIHR	16.4
3	SSHRC	36.0
	Subtotal Individual Research Council Funding Programs	**233.4**
	Tri-Council Funding Programs	
4	*Business-Led Networks of Centres of Excellence*	11.5
5	*Centres of Excellence for Commercialization and Research*	57.0
	Subtotal Tri-Council Research Funding Programs	**68.5**
	National Research Council of Canada	
6	IRAP (notional allocation of 17% of total IRAP budget of $ 137.6 M in 2010-2011. Excludes stimulus spending)	23.4
7	NRC Cluster Initiatives (notional allocation of 10% of total expenditures on cluster initiatives)	8.3
8	NRC Institutes (notional allocation of 10% NRC spending on its Institutes in 2009-2010)	30.0
	Sub-total NRC	**61.7**
9	**Federal Regional Development Agency Programs**	5.0
	ESTIMATE OF TOTAL FEDERAL FUNDING WITH ENCOURAGING U-B COLLABORATION AS A PRIMARY OBJECTIVE	**368.6**
	Other illustrations of annual federal funding, some portion of which might be also be attributed to achieving U-B collaboration objectives	
	CANARIE	24.0
	Precarn	4.0
	CMC Microsystems	8.0
	Tri-Council Networks of Centres of Excellence (NCE) Program	71.8
	Sector Skills Councils	40.0
	SR&ED Tax Credit (projected tax expenditures 2010)	3,500.0

Sources and Notes

1. **NSERC Partnership Programs.** NSERC's Departmental Performance Report 2009-2010 reports that expenditures on its main programs that may be most associated with U-B collaboration (Strategic Project Grants, Collaborative Research and Development Grants; Strategic Network Grants, Industrial Chairs Program, Ideas to Innovation Program; Interaction Grants Program; and Engage Grants Program) totaled C$ 181 million in 2009-2010. This estimate excludes expenditures for Tri-Council network programs. This estimate is likely very conservative. NSERC stated: "Private-public sector partnerships generate the kind of innovation that leads to business growth, job creation and a stronger, more resilient

economy. NSERC's new *Strategy for Partnerships and Innovation* builds on NSERC's current investments of approximately $300 million/year in partnered R&D. These lever more than $120 million annually from more than 1,500 Canadian companies. The Strategy aims to connect and apply the strengths of the post-secondary research system to industry for the benefit of Canadians. Designed to attract more Canadian companies to invest in R&D projects with Canadian universities and colleges, it will result in higher value products, processes and services produced in Canada." (GOC, 2010c: 4) [emphasis added].

2. **CIHR Technology Transfer and Commercialization Programs.** CIHR's *Report on Plans and Priorities* (RPP) for 2010-2011 reports that the forecast spending under the object of "Health Research and Commercialization is C$ 51.1 million for 2009-2010. However, some portion of this amount represents funding for tri-council programs (e.g., NCEs). According to CIHR's RPP, C$ 16.4 million of C$ 51.1 million represents CIHR's own Research Commercialization Programs: "The Research Commercialization Programs are a suite of funding initiatives that aim to support the creation of new knowledge, practices, products and services and to facilitate the commercialization of this knowledge. This is done by funding research commercialization projects (such as proof of principle projects) which encourage collaboration between academia and industry in the promotion and support of the commercial transfer of knowledge and technology resulting from health research."

3. **SSHRC Strategic Outcome: Knowledge Mobilization—Facilitating the Use of Social Sciences and Humanities Knowledge Within and Beyond Academia.** According to the SSHRC's 2009-2010 *Department Performance Report*, this Strategic Outcome involves: "Moving new knowledge from academia into areas where it can be applied more directly to the benefit of Canadians has been a dominant theme in SSHRC's strategic planning for several years. SSHRC understands this challenge in the broadest sense: that it is not merely about "transferring" knowledge after it has been produced, but also about allowing opportunities for practitioners and other research users to participate and influence the knowledge-production process from the beginning. Knowledge mobilization is a key strategy for realizing Canada's Entrepreneurial Advantage." SSHRC expenditures in support of this Strategic Outcome (and which are assumed here to be most closely aligned with encouraging U-B collaboration) amounted to C$ 36 million in 2009-2010. This amount excludes the Canada Research Chairs Program (C$ 62 million in 2009-2010) and the Community-University Research Alliances Program (C$ 12 million in 2009-2010).

4. **The Tri-Council Business-Led Networks of Centres of Excellence program (BL-NCEs).** The total funding for this program announced in Budget 2007 was C$ 46 million over four years. For present purposes, a notional amount of C$ 11.5 million per year is included in the U-B collaboration funding table. Whether this program will receive new funding in the future is not known.

5. **The Tri-Council Centres of Excellence for Commercialization of Research Program**. The total announced funding for this program is C$ 285 million over five years. For present purposes, a notion amount of C$ 57 million per year is included in the U-B collaboration funding table. Whether this program will receive new funding in the future is not known.

6. **National Research Council of Canada (NRC), Industrial Research Assistance Program (IRAP).** As discussed in this report, while IRAP is not presented by the NRC as a program to encourage U-B collaboration, it may be judged to have that effect. NRC's *Report on Plans and Priorities* for 2010-2011 reports that its total planned spending through IRAP for 2010-2011 is C$ 137.6 million. (This amount excludes additional monies allocated to IRAP as part

of the federal government's stimulus package). How much of this amount might be notionally allocated to encouraging U-B collaboration? We know that approximately 40, or 17 percent, of IRAP's 230 Industrial Technology Advisors work out of university facilities. For present purposes this same percentage, 17 percent, is applied to IRAP's total annual budget to arrive at an amount that might be allocated to encouraging U-B collaboration (i.e., C$ 23.4 million).

7. **The National Research Council of Canada (NRC), Cluster Initiatives**. It is difficult to extract from either the NRC's *Report on Plans and Priorities* or its *Departmental Performance Report* how much it is spending annually on its technology cluster initiative. For present purposes, reliance is placed on the NRC's own *Portfolio Evaluation of NRC Technology Cluster Initiative* (2010). The evaluation finds that NRC's direct regional investment in cluster initiatives between 2000-01 and 2007-08 totaled C$ 342 million. This amounts to C$ 48.9 million over each of the seven years. How much of this amount might be notionally allocated to encouraging U-B collaboration? For present purposes, a notional 17 percent share is applied (i.e., C$ 8.3 million). This is likely a very conservative estimate, since the whole point of cluster policy is to draw together geographically proximate knowledge assets.

8. **The National Research Council of Canada (NRC) research institutes.** It is difficult to extract from the NRC's *Report on Plans and Priorities* or its *Departmental Performance Report* how much it is spending annually in its 26 research institutes. A notional amount of C$ 300 million annually (likely a significant underestimate) is selected here based on the publicly available information. (NRC's institutes also obtain funding from other governmental and non-governmental sources). How much of this amount might be notionally allocated to encouraging U-B collaboration? A low allocation percentage of 10 percent is applied here (i.e., C$ 30 million).

9. **Federal Regional Economic Development Agencies.** How much these agencies are spending to directly encourage U-B collaboration is not known. This report provided a number of examples which suggests the amounts involved may be considerable. However, given the absence of any research, a notional amount (probably far too low) of C$ 5 million annually for all the agencies is used.

ANNEX V

Sources and Notes for Exhibit I from the Executive Summary of this Report on Selected University-Business Research Collaboration Indicators

	INDICATOR	Degree of International Comparability	Canada	US	UK	Australia	Other Jurisdictions
1	**World Economic Forum country rankings on university-business (U-B) R&D collaboration.** Reference Period: 2010	High	**7**	**1**	**4**	**13**	**Switzerland: No. 2** **Finland: No. 3** **Sweden No. 5** **Singapore: No. 6**
2	**WEF ten year average score on U-B R&D collaboration (1= do not collaborate, 7 = collaborate extensively).** Reference Period: 2001-2010	High	**5.0**	**5.6**	**5.1**	**4.5**	**2001-2010 Average Score for Top 30 countries in 2010: 4.7**
3	**IMD World Competitiveness Yearbook Country Ranking on Knowledge Transfer between business and universities** Reference Period: 2010	High	**8**	**2**	**15**	**18**	..
4	**Share of total HERD funded by the business sector.** Reference Periods: 2008	Medium	**8.5%**	**5.7%**	**4.6%**	**4.9%**	**OECD: 6.2% (2007)**
5	**R&D funded by business sector and performed by higher education sector as percent of GDP.** Reference Periods: Australia 2008; all others 2007	Medium	**0.06%**	**0.02%**	**0.02%**	**0.03%**	..
6	**Share of total business sector R&D funding performed by the Higher Education sector** Reference Periods: Australia 2008-2009; all others 2007.	Medium	**6.2%**	**1.1%**	**2.5%**	**2.1%**	..
7	**Share of industry S&T papers written in collaboration with an academic institution.** Reference Periods: Canada (2005); US (2008)	Medium	**55.0%**	**53.8%**	..	..	
8	**University commercialization staff per US $100 million in research expenditures.** Reference Periods: Canada, US and Australia, 2008; UK 2005	Low	**7.9**	**5.0**	**19.6**	**8.6**	..
9	**Universities: invention disclosures per US$ 100 million in research expenditures in 2004**	Medium	**32.0**	**40.4**	**51.6**	**25.4**	**EU: 33.3**
10	**Universities: Patent applications per US$ 100 million in research expenditures in 2004**	Medium	**29.7**	**25.5**	**15.1**	**9.5**	**EU: 9.5**
11	**Universities: Patent grants per US$ 100 million in research expenditures in 2004**	Medium	**4.9**	**8.8**	**3.1**	**8.2**	**EU: 3.8**
12	**Universities: Licenses executed per US$ 100 million in research expenditures in 2004**	Medium	**11.3**	**11.0**	**36.7**	**9.5**	**EU 8.3**
13	**Universities: Start-up companies formed per US$ 100 million in research expenditures in 2004**	Medium	**1.5**	**1.1**	**2.8**	**0.8**	**EU 2.8**
14	**Universities: Licence Revenues as percent total university research expenditures in 2004**	Medium	**1.0%**	**2.9%**	**1.1%**	**1.8%**	**EU 1.2%**
15	**Number of SMEs collaborating in innovation with HE sector as percentage of all firms. Data for Canada and France covers manufacturing sector only.** Reference Periods: Canada, '02-'04; UK and other EU, 04'-'06; Australia, '06-'07.	Low	**4.2%**	..	**3.1%**	**3.1%**	**OECD: 3.9%** **Finland: 16.3%** **Austria: 6.9%** **France: 6.3%**
16	**Number of large firms collaborating in innovation with HE sector as percentage of all firms. Data for Canada and France covers manufacturing sector only.** Reference Periods: Canada ('02-'04); UK and other EU ('04'-06); Australia ('06-'07).	Low	**11.9%**	..	**9.4%**	**10.0%**	**OECD: 21.9%** **Finland: 59.1%** **Slovenia: 41.3%** **Austria: 35.8%**

Sources and Notes for the Exhibit I on Selected University-Business Collaboration Indicators

General Note:

Column Two, "Degree of International Comparability" (high, medium or low) reflects the author's qualitative judgement on the extent of international comparability of the reported indicators of U-B collaboration. Some indicators have a very low degree of comparability because of different reference periods or scope of institutional or sectoral coverage. However, indicators judged to have a "high" degree of international comparability (e.g. the World Economic Forum's Executive Opinion Survey results) are not inherently better than alternative indicators.

Sources and Notes for each Indicator

1. World Economic Forum *Global Competitiveness Report*, 2010. Discussion of this indicator starts on page 40 of this report.

2. Assembled by the author from World Economic Forum *Global Competitiveness Report*, annual issues 2001-2010. Discussion of this indicator starts on page 40 of this report.

3. IMD *World Competitiveness Yearbook* (2010). Discussion of this indicator starts on page 42 of this report.

4. OECD, *Main Science and Technology Indicators* Vol. 2010/1. Data for Australia for 2007 is not included is MSTI Vol. 2010/1. Australian data for 2008 is drawn from the Australian Bureau of Statistics *Research and Experimental Development Bulletin* 8111.0, May 2010, Table 4. Discussion of this indicator starts on page 22 of this report.

5. OECD.Stat for 2007. Australian data for 2008 (not included in the OECD database at this time of writing) is sourced from the Australian Bureau of Statistics *Research and Experimental Development Bulletin* 8111.0, May 2010. Discussion of this indicator starts on page 22 of this report.

6. OECD.Stat for 2007. Australian data for 2008 (not included in the OECD database at this time of writing) is sourced from the *Research and Experimental Development Bulletin* 8104.0, September 2010, Table 7 (total own source business expenditures on Research and Experimental Expenditures) and Australian Bureau of Statistics *Research and Experimental Development Bulletin* 8111.0, May 2010, Table 3 (total business funding of higher education research and development). Discussion of this indicator starts on page 22 of this report.

7. Labeau, Laframboise, Lariviére and Gingras (2008) for Canada and the US National Science Board, *Science and Engineering Statistics* (USG, 2010s) for the US. Discussion of this indicator starts on page 30 of this report.

8. Different surveys use different definitions for estimates of university staff involved in commercialization or "technology transfer" activities and likely have low international comparability. The estimates presented here are drawn from: Canada for 2008 (Statistics Canada, Catalogue No. 88-222-X); the US for 2008 (Association of University Technology Managers (AUTM) Licensing Activity Survey); the UK for 2005 (UNICO UK, University Commercialisation Survey, Financial Year 2005); and Australia for 2008

(Knowledge Commercialisation Australasia Inc. Commercialisation Metrics Survey Report 2008). Based on these sources, university full time equivalent staff for commercialization or technology transfer activities were: 321 (Canada 2008); 2,092 (US 2008); 1,154 (UK 2005) and 363 (Australia 2008). University research expenditures for each of the four jurisdictions in 2004 are used to normalize this data across jurisdictions. This is far from a satisfactory approach (it reflects the research resources and data available to this author) and future research should use consistent data sets for both the numerator (staff) and denominator (research expenditures). Nonetheless, the results reported here are not out of line with anecdotal reports and other sources of information. For example, the UK appears to have the highest number of commercialization staff (in 2005) per US$ 100 million in research expenditures (in 2004), and this may reflect the large financial resources given for employing such staff through the UK's "third stream" funding. See discussion starting on page 199 of this report.

9 – 14. Except for Canadian patent grants and start-ups, these indicators for 2004 are those reported by Arundel and Bordoy (2008) and are derived from various surveys (Statistics Canada, AUTM, Australian Bureau of Statistics, UNICO, ASTP Europe, and the Higher Education Funding Council for England). The indicators for Canadian patent grants and start-ups are reported by Clayman (2007) based on AUTM survey data. Discussion of these indicators starts on page 32 of this report.

15. OECD Scoreboard 2007 and 2009. Small firms defined as between: 10-249 employees for Europe, Australia and Japan; 10-99 employees for New Zealand; 10-299 employees for Korea, and 20-249 employees for Canada. Discussion of this indicator starts on page 31 of this report.

16. OECD Scoreboard 2007 and 2009. Large firms: > 249 employees for European countries, Australia and Japan; >99 employees for New Zealand; >299 employees for Korea; and >249 employees for Canada. Discussion of this indicator starts on page 38 of this report.