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FROM FIELD SURGERY TO ADVANCED ROBOTICS:

SINO-CANADIAN RELATIONS IN SCIENCE AND TECHNOLOGY, 1938 TO 2018

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UNIVERSITY OF ALBERTA
CHINA INSTITUTE

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FOREWORD

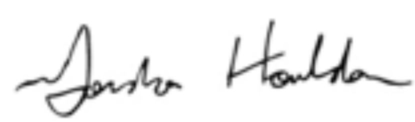
The China Institute is pleased to publish this Occasional Paper on the subject of science and technology development and partnerships between China and Canada. This is the second publication by the China Institute on China's science and technology.

Today, China is a leading innovator in many science-related fields, including robotics, artificial intelligence, medical technology, space exploration, and renewable energy production. However, China's success story in science and technology was advanced, in part, by historical support and partnerships with Canada. Collaboration among scientists, universities, businesses, and national governments spanning eight decades, developed research potential in both Canada and China, and created invaluable relationships that generated and continues to generate extensive technological and scientific innovation in both countries.

This paper examines the role that Canada played in the development of China's scientific and technological capacities, and documents the interpersonal relationships that fostered this development. The paper begins with a chronological overview of key events and collaborations between Canada and China, and explores the significance of these partnerships over time. It then highlights key players, and illuminates significant institutional elements of China's development. The paper also touches upon some of the challenges that have emerged in scientific and technology collaboration with China. Policymakers, elected officials, academics, and industry leaders who seek to operate and foster partnerships in China will find this paper of importance.

As the Trudeau Government seeks closer ties to China, our own development will be reinforced by utilizing and strengthening the network of Canadian and Chinese researchers, which after eight decades of interaction, continues to grow.

Beyond the acknowledgements listed in the text, I wish to thank CIUA members Michaela Pedersen-Macnab and Marija Pavleska for their editorial support, Genevieve Ongaro for her design and formatting contribution, and Erin Asselin and Jia Wang for their contributions on project coordination. As well, I wish to thank the reviewers of this paper, both academic and governmental, for their contributions.



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ABOUT THE AUTHOR

Over a 37 year government career, **Margaret McCuaig-Johnston** held senior positions in S&T policy, programs and funding including at the Natural Sciences and Engineering Research Council, Natural Resources Canada, Department of Finance, Industry Canada and the Privy Council Office, the Prime Minister's department. For seven years she was a member of the Canada/China Joint Committee on Science and Technology. She has a Masters of International Relations focussed on China from York University and an Honours Bachelor of Political Economy from the University of Toronto. Her first of many visits to China was in 1979. The author would like to acknowledge her ISSP colleagues Paul Dufour, Jonathan Linton, Moxi Zhang and Visiting Professor Li Yan of the Chinese Academy of Science and Technology for Development for their assistance in the preparation of this research, as well as the many officials both current and retired who were interviewed or provided background for this paper.

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EXECUTIVE SUMMARY

For eight decades, Canada and China have engaged in an increasingly rich and comprehensive collaboration in science, technology, and innovation. Beginning with the personal engagement of some of the most prominent innovators of both countries in the 1930s through the 1960s, it was realized that China was building on millennia of leadership in innovation while Canada was in the forefront of Western advances in key areas of research. The purpose of this occasional paper is to outline significant collaborations and initiatives among Canadian and Chinese government, industry, and academic researchers, as well as to highlight the role Canada played in China's transition from developing country to a driver of global technological innovation.

Medical innovators, such as Dr. Norman Bethune and Dr. Wilder Penfield, and geologist and science museum director Dr. Tuzo Wilson made significant personal contributions to Sino-Canadian collaboration. As China began to open up to the West in the late 1970s, Canada's development aid was frequently focused on helping China build capacity. The International Development Research Centre provided significant assistance over the years in technology transfer and building scientific capacity. Similarly, the Canadian International Development Agency played an important role in training and technical assistance in agriculture, forestry, energy, transportation and telecommunications, along with the scientists of Canadian government departments such as Agriculture Canada. The collaborative China Council for International Cooperation on Environment and Development has provided a long-standing forum for leaders in both countries to engage on ways to advance China's science policy capacity.

Over the decades, strong academic linkages have developed --- in the first instance from the leadership of individual scientists, building into institutional exchanges. One of the important facilitators of these collaborations has been the strong Chinese diaspora in the Canadian research community. Some of Canada's top researchers are of Chinese origin, and this is one of the explanations for the tremendous increase in bilateral research collaborations. Canadian universities and colleges now receive more than 130,000 Chinese students per year, and many of these students choose to stay in Canada for their careers. They in turn are often collaborators with mainland Chinese researchers, and returning students often continue their collaborations with Canadian researchers.

Canadian technology companies too have had long-standing relations with China. Companies like Nortel, Bombardier, Ballard, Candu Energy Inc., and others have had extensive engagements in and with China over the last few decades. Chinese technology companies such as Huawei now have a strong presence in Canada. And start-up incubators and accelerators in both China and Canada have linkages with their counterparts. There are mutual benefits from business-to-business engagement, and the prospects for the negotiation of a Canada-China Free Trade Agreement promise a further exchange and deepening of technology advances in both countries.

Government-to-government engagement on science and technology relations has been a backdrop to the collaborations going on in academia and business. Having had two extended visits to China before becoming Canada's Prime Minister, Pierre Trudeau's government recognized China in 1970, one of the first Western governments to do so.

With Reform and Opening announced by Deng Xiaoping in 1978, the Government of China started to send delegations to Ottawa to discuss the potential for science and technology collaboration. Canada's government departments signed memoranda of understanding with their Chinese counterpart ministries covering areas such as agriculture, earthquake, environmental and medical research exchanges. Most often, this collaboration involved Chinese scientists coming to Canada for a period of months, and sometimes the reverse, as well as pilot projects in China testing Canadian methods in a new context. China absorbed new Canadian approaches and ideas wherever the Chinese government saw that they could improve their country's S&T base, economy, and citizens' lives.

The Government of Prime Minister Brian Mulroney in the 1980s developed a China Strategy and was on a trajectory for a much more ramped up engagement when the Tiananmen events brought such plans to a stop. Collaboration was not reactivated until the mid-1990s when the Government of Prime Minister Jean Chretien began annual "Team Canada Missions" of hundreds of government, business and university leaders going together to China for maximum government-to-government impact. Prime Minister Paul Martin brought a science, technology and innovation focus to bilateral relations with a Canada-China Strategic Working Group, a new funded program to support collaboration, a Declaration on Science and Technology Cooperation, and a joint expert team to advise on "Complementarities in Science and Technology".

The Government of Prime Minister Stephen Harper, while cool initially to bilateral relations with China, responded positively to the report by an expert team on Complementarities that focused on energy, environment, health/life sciences/biotechnology and agriculture foods/bio-products. Nanotechnology and ICT were seen as enabling technologies across many sectors. In 2007, Canada and China signed an Agreement for Science and Technology Cooperation supported by the Canada-China Joint Committee on Science and Technology. On Canada's side, it is a government-wide agreement with treaty status, encompassing all departments. With the funded program under the auspices of International S&T Partnerships Canada, nearly two dozen projects were jointly approved, funded and implemented involving companies and universities from both countries. However, bureaucratic and management challenges led the Canadian side to a reconstitution of the program as the Canadian International Innovation Program, which funds research with China and several other countries. It is managed by the Industrial Research Assistance Program of the National Research Council. During this period, China underwent major S&T program changes, and while most ministry program functions were delegated to arms-length professional agencies, the International Program of the Ministry of Science and Technology was retained in the ministry for ease of administration when partnering with other countries.

Now, with a new focus on China by the Government of Prime Minister Justin Trudeau, and the prospect of the negotiation of a Free Trade Agreement, collaboration in science, technology, and innovation is expected to accelerate in the coming years. On the policy front, it will be important to keep open bilateral discussions on the challenges of business and academic technology engagement such as intellectual property, collaboration mechanisms, and joint business models. The planned Innovation Dialogue to be launched in 2018 will provide an important platform for these discussions. And Canada can learn from the detailed STI Strategies and Plans developed in China in the past several years – not just for what they reveal about future areas of collaboration but for the comprehensive design of the strategies themselves. There is significant potential for Canada and China to build upon our historic collaboration in the coming years.

1. INTRODUCTION

Eight Decades of Engagement and Collaboration

For millennia, China led the world in science and technology. Innovations such as paper, fireworks, silk, paper money, clocks, umbrellas, type printing, seismographs, porcelain, iron smelting and seed drills made their way over the years to other countries, where they were incorporated into their societies. China's leadership in science and technology was documented thoroughly by Cambridge University's Dr. Joseph Needham in his 21 volumes of Science and Civilisation in China.[1] But many years of political turmoil in the 1800s and early 1900s, including the opium wars, warlords, the Japanese occupation and the communist revolution did not provide the stability for scientific advances. Even after the assumption of power by Mao Zedong in 1949, turmoil continued with the Hundred Flowers campaign and its fallout, the Great Leap Forward and the Cultural Revolution, when universities were closed for years. It was not until the Reform and Opening policy, announced by Deng Xiaoping in December 1978 that the country's science and technology research and innovation were again given top priority.

The relationships that develop between Chinese scientists and engineers and those in other nations are not like the rational transactional exchanges that have become the norm with most other countries. Rather than "transactional", they are "relational", depending upon years of engagement and mutual trust. The popular expression *guānxì* reflects the importance of "connections and networks" in the work environment and personal lives of the Chinese, but does not quite capture the *xìn* or real "trust" necessary for good collaboration in the sphere of science and technology that is a requirement for engaging on S&T or R&D in China.

This paper will cover Canada-China science, technology and innovation (STI) relations over eight decades. It will look at the early *xìn* that developed between Canadian and Chinese researchers, particularly during periods in China's history when the country really needed the help in medicine, agriculture and development aid that Canadians could provide. The paper will then go on to discuss the deepening of Canada/China academic, industry and government relationships in science, technology and innovation over the years. The paper will conclude with reflections on the potential for future collaboration. As China emerges as a nation driven by innovation, it should be remembered that Canada played an important role in bringing that country to this stage in its development. Going forward, it will be critical for Canada and China to cement a viable science and technology partnership for the mutual benefit of both. As with all dimensions of Canada's relationship with China, such a partnership requires time, effort and resources invested. It will also need a sustained and consistent focus on the long term objective of the collaborative advancement of science, technology, and innovation in both countries.

2. BUILDING SCIENCE AND TECHNOLOGY CAPACITY IN CHINA

The Early Years of Engagement and Development Assistance

Through the decades following 1949, Canadians visiting China have been received with warmth and friendship. This stems in the first instance from the sacrifice of Canadian Doctor **Norman Bethune**.[2] He had joined the Communist Party in 1936 to help in the Spanish Civil War where he organized the first mobile blood transfusion service. After returning to Canada to raise funds for Communist efforts, he left again in 1938 to help the Communists in the Shanxi-Hobei border region of China. Bethune is the first Canadian innovator to help the Communist Party of China's Eighth Route Army --- his innovations of 12 medical and surgical instruments were put to work in the field, including the 'Bethune Pneumothorax Machine' pictured[3] at right and the Mobile Blood Transfusion Unit he invented in the Spanish Civil War. Bethune also authored 14 articles on thoracic techniques,[4] and is credited with helping to bring modern medicine to rural China. Bethune died in 1939 from blood poisoning, following an operation in the field. Generations of Chinese students were taught to revere *Bái Qiúēn*, to recite Mao's eulogy of him, and to emulate his life of service.[5] At Canada/China events today, the name of Norman Bethune is still frequently mentioned as a representation of longstanding positive Canada/China relations. This is somewhat ironic given that Canadian governments of that era as well as our own time would not embrace Bethune's communist leanings.

Bethune Pheumothorax Machine. Credit: Osler Library of the History of Medicine, McGill University.

Norman Bethune in China. Credit: Wang, Top 9 Famous Foreigners in Chinese History.

Dr. Wilder Penfield Credit: www.ericberne.com/wilder-penfield-biography/

Bethune's contributions to China were followed by those of the world renowned McGill neurologist **Dr. Wilder Penfield**. In 1938-39, Penfield had trained and mentored **Dr. Zhao Yi-Cheng** at McGill, treating him as part of the Penfield family. Dr. Zhao had returned to China to become the country's first neurosurgeon, being asked by the Communist Government to lead a neurological unit in Beijing which became the Tianjin Neurological Institute. In 1943 and again in 1962, Dr. Penfield and his wife visited China. In 1962, the Government asked Dr. Zhao and his wife to host them for visits to labs, institutes and historical sites as well as at the National Day Celebration, and they had an extensive and friendly talk with **Chairman Mao** at Tiananmen. This was the first of many exchanges, and it led directly to an academic exchange program between McGill University and Peking University (*Běidà*). Dr. Zhao is known as the founder of neurosurgery in China and trained more than 200 Chinese neurosurgeons.[6]

In August of 1958, **Professor Tuzo Wilson** of the University of Toronto, and Council member of the National Research Council of Canada (NRC) from 1958 to 1964, attended a meeting of scientists from sixty-six countries in Moscow for the planning of the International Geophysical Year. He decided to return home via the Trans-Siberian railway to spend one month touring throughout China, hosted in each city by the Chinese Academy of Sciences (CAS). During this trip, he visited geophysical institutes and universities, as well as important regions vulnerable to earthquakes. It was the first visit of the NRC to China since 1949. Dr. Wilson wrote a book about his positive impressions of his month in China[7], and went on to become President of the Royal Society of Canada, President of the American Geophysical Union, a member of the Science Council of Canada, and the first Director General of the Ontario Science Centre. In 1982 he organised an exhibition at the Centre of Chinese scientific artefacts representing innovations in China over 7,000 years[8]; at the time, the display was said to be "the most spectacular exhibition of ancient Chinese science and technology ever assembled outside China", and after worldwide study, the Ontario Science Centre was chosen as the model for the Beijing Science Centre.[9] The collaborations that Dr. Wilson began in geoscience continue to this day, and these relationships are of great importance to both Canada and China. In his early years Dr. Wilson had worked for the Geological Survey of Canada (GSC) that is now part of the Lands and Minerals Sector of Natural Resources Canada (NRCan). The GSC has enjoyed extensive relations in China in the years since Dr. Wilson first visited the country, particularly with respect to earthquake and landslide research, which is of such importance in China.[10]

Professor Tuzo Wilson

In the early 1960s, at a time of great hunger and poverty in China, the government of Prime Minister John Diefenbaker provided much needed Canadian grain.[11] In 1970, the government of Prime Minister Pierre Trudeau was one of the first Western Bloc countries to recognize the People's Republic of China, behind only the UK and France. This stemmed at least in part from the fact that Trudeau himself visited China in 1960, travelling throughout the countryside during the Great Leap Forward. He wrote a book about his impressions of a China that few Westerners understood in those early days.[12] In 1971, Canada voted in favour of the People's Republic of China taking its seat in the United Nations, and in 1973, Prime Minister Trudeau made an official visit to China. While these events do not relate directly to research and development, they were very important elements in the developing mutual respect, collaboration and trust between our two countries. Prime Minister Trudeau's visits provided a foundation of positive goodwill that has lasted decades in the Chinese psyche. This in turn has been a good contributor to positive relations over the years in science and technology.

While the early years of S&T collaboration were ad hoc and dependent upon warm bilateral collaborations between stellar scientists in both countries, beginning in the 1970s, Canada-China relations were characterised by Canadian development projects in China that often had an R&D dimension. These collaborations were designed to develop China's capacity, particularly in environment, resource, and industry sectors. According to B. Michael Frolic, early discussions between the two countries took place between 1974 and 1979 in the areas of "… geology, oceanography, remote sensing, metallurgy, coal mining, railways, ports, agriculture, forestry and fisheries. PRC missions came to Canada and learned about Canadian technology and often made commercial contracts at the same time".[13] Very soon, development assistance through S&T, as well as related governance advice was offered through two of Canada's development agencies, the International Development Research Centre and the Canadian International Development Agency. Both were active in China for decades, usually in complementary roles, thereby helping China to evolve from a developing country to a developed nation.

The **International Development Research Centre** (**IDRC**) is a Crown corporation charged with helping developing countries to apply new knowledge to the economic and social improvement of their societies. The Centre identifies and analyses emerging challenges in the given country using its own staff of senior researchers and program officers and its international network of experts and funds researchers in the country being assessed. These teams work with leaders at national, provincial, and local levels to analyse the issues, develop pilot or experimental initiatives, document the options and recommendations, and assist with implementation plans. IDRC has worked in China for thirty-six years and is among the world's top ten funders of development research.[14] In fact, in 1979, an IDRC project was Canada's first personnel exchange involving technology transfer to China, and indeed this was the first formal entry by any country into a bilateral development assistance relationship with China.[15] In China, IDRC has worked across all program lines (agriculture; water and environment; global health policy (e.g. infectious disease response practices); science and innovation; and social and economic policy) to identify solutions and link Chinese institutions with their Canadian counterparts.

While its work has provided many practical sectoral solutions, it has also taken a broader view of China's science and technology challenges and opportunities. From time to time, IDRC has taken a step back to assess, with Chinese partners, the country's overall performance in science and technology policy. Such a project was begun in 1995 under the leadership of the U.K.'s Dr. Geoffrey Oldham, reporting in 1997 to Zhu Lilan, Member of the State Council Leading Group on Science and Technology, and Executive Vice-Minister of the then State Science and Technology Commission. This analysis identified, for example, the benefits of China's participation in big science projects and the need for a more explicit policy for international collaboration, while noting positively the flexibility of its approach for experimentation appropriate to different conditions. China's governmental response to the report indicated that a new international S&T collaboration strategy was being formulated in order to strengthen the links between S&T collaboration and trade; increase cooperation on industrial and advanced manufacturing technologies; assist R&D institutions to establish branches overseas; create a national fund for international S&T cooperation; and explore channels for China's participation in big science projects.[16]

IDRC went on to initiate a major project in 1997 on the Chinese National Strategy for International Science and Technology Cooperation which analysed past experiences of China's international S&T collaboration, identified costs and benefits, brought together external and domestic experts, and reviewed the experience of other countries. As part of this process, China's Ministry of Science and Technology (MOST) convened national workshops, commissioned case studies and issue papers, and convened an international workshop to review the findings. The project was completed in 2001, and concluded that, to date, China had been a "modest contributor to major international S&T debates and was on the sidelines of most international fora in which these debates occur". It recommended more direct engagement in Big Science, and a strategic orientation of China's international assistance for other developing countries. MOST followed up in each of these areas, and in a broader 2007 study of "Emerging Donors in International Development Assistance", IDRC documented the growth of China's substantive contributions to development assistance generally, and research for development more specifically. Interestingly, this report notes that all of China's bilateral aid is *tied* aid including research and development assistance grants and technical assistance.[17] On the other hand, an IDRC Report in 2000 entitled *An Assessment of Twenty Years of Research Collaboration between China and the IDRC* highlighted the fact that IDRC's aid was intended to benefit China rather than Canada, and that this was greatly appreciated by the Chinese recipients,[18] though IDRC managers and scientists point out that Canada has also benefitted from its projects in China over the years.[19] Other benefits of IDRC's work in China identified in this report included project management skills as a best practice, the introduction of Chinese research teams to regional and global networks, valuable networking among research groups within China, and training opportunities, among others. At the same time, the report identified opportunities for improvement in IDRC's processes in China, including longer visits in the field, shorter response time for project proposals, and longer project cycles.[20]

These reports are a few of the broader S&T policy-related IDRC analyses over the years; its sectoral, social science and other focussed reports have similarly helped China to develop and enrich its R&D capacity and performance. IDRC's Vice President **Dr. Stephen McGurk**, for example, has spent more than 30 years studying Asia's rural development, and developing with Chinese counterparts the country's rattan and bamboo industry and capacity, among other sectors. In this photo, the delegation of the International Center for Bamboo and Rattan of the State Forestry Administration of China, led by the Co-Chair of its Board, Madam Jiang Zehui, Vice-Chair of the Subcommittee of Human Resources and Environment of the Chinese People's Political Consultative Conference met with Canadian officials including Dr. McGurk, sixth from the left.[21]

http://ca.china-embassy.org/eng/sgxw/t1412402.htm
Credit: Chinese Embassy, Ottawa.

However, IDRC's success does not rest as much on the reports it has produced as on the collaborative and iterative process that it employs in China, working with those who will benefit from its insights and proposals, so that they will be in a position to take action.[22] And IDRC continues to work on a broad range of initiatives in China including reducing the impacts of climate change on water and agriculture sectors, as well as emerging and re-emerging infectious disease and eco-health – projects which are of high priority in Canada's government-to-government S&T relations with China which will be discussed below.

The Canadian International Development Agency (CIDA) too played a very important role in China over the decades. Starting in 1981, CIDA (now merged into Global Affairs Canada (GAC)) provided substantive and significant development assistance in China that frequently had research, science or technology dimensions.[23] While GAC no longer maintains a development assistance program in China, CIDA's past role in China is significant and therefore merits discussion here.

The early strategy for CIDA's China Program was to invest scarce resources in human development assistance (e.g. training) and "technical assistance" in six sectors: education and training, agriculture, forestry, energy, transportation, and telecommunications.[24] Each of these had a significant S&T and/or R&D dimension. One CIDA initiative in particular had a lasting effect: that is CIDA's role in establishing the China Council for International Cooperation on Environment and Development (CCICED), mentioned above. Many projects were undertaken in the 1980s, but the tragic events at Tiananmen in 1989 resulted in the Canadian Government cancelling or postponing many projects, including some which affected the S&T connections at that time. Among the cancelled projects were the Lanzhou Lubricating Oil Evaluation Centre ($2.23M) and the Urban Traffic Management Project ($4.82M). Postponed projects included Oil and Gas Technology Transfer, Tanggua Animal Quarantine Upgrading, Comprehensive Transport Management, and Guangzhou Air Traffic Control.[25]

In the 1990s and 2000s, CIDA used other Canadian government agencies in addition to its own agency staff to deliver projects with China. For example, the Hebei Dryland Project ($4.9M) was implemented by Agriculture and Agri-Food Canada as it provided the advantage of agriculture science specialists in the field, so to speak, which resulted in direct technology transfer. Research included development and selection of drought-tolerant cultivars and preparation of more scientifically-based soil and water resource plans; Hebei Academy of Agriculture and Forestry Science was the university/college partner. Two five year (2003-2008) CIDA projects relating to "small farmers" and sustainable agriculture had enormous impacts by training 42,940 Chinese participants in 615 capacity building training programs, 36 of which were hosted in Canada. Food safety was a major impact of the first, winning the prestigious Sannong Award in 2008, while the second transferred sustainable agriculture technologies through trained extension workers, among other impacts.[26] Another CIDA science-related agriculture project related to improved potato production where one outcome was the development of a potato that had previously only been usable for starch became a table potato used at the Beijing Olympics, based on Canadian expertise and technology transfer.[27]

One Agriculture Canada initiative that stands out as having huge impact in China is that of **Dr. Vern Burrows**, a Canadian government scientist who specialized in oats research. Dr. Burrows knew of a Canadian series of hearty oats that could grow almost anywhere, and in the 1990s he worked with Chinese scientists on oat production in Jilin province by mixing thirty varieties of Canadian oats with local Chinese oats. His research found that when eight Canadian varieties were blended with Chinese oats, a much heartier local variety could be produced that vastly increased the production of oats in China --- most importantly in regions where successful agriculture had previously been thought to be impossible.[29] Dr. Burrows' research also brought benefits back to Canada in new strains of oats. In China he was honoured with the Friendship Award of China in 2003, and despite China's practice of not erecting monuments to people who are still living, a bronze bust of Dr. Burrows was unveiled in 2012 at the Baicheng Academy of Agricultural Sciences. **Dr. Ren Changzhong**, President of the Academy and a former student of Dr. Burrows declared at the ceremony that Dr. Burrows is "revered by the Chinese people and praised as an international friend in the style of Canada's Dr. Norman Bethune". And back home in Canada, Dr. Burrows was awarded the "Agcellence Award in Innovation" in 2000 and the Order of Canada in 2001[30] --- the highest honour awarded to Canadian citizens. Since then, Agriculture Canada and its ministry partners in China have established six joint agricultural

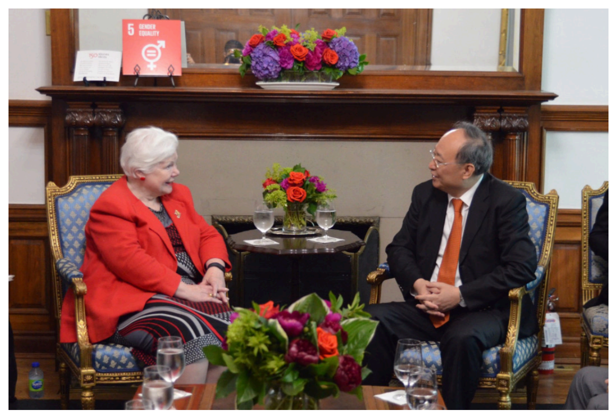
Dr. Vern Burrows and Dr. Ren Changzhong. Credit: Ministry of Science and Technology, Government of China

science and innovation centres across China, with the support of universities and industries in both countries.[31] Indeed, Dr. Burrows is now catching up to Dr. Bethune as the most frequently mentioned Canadian contributor to China's research and development, especially by the Chinese in their frequent and heartfelt toasts.

In the development of China's policy capacity in environmental science and climate change Canadians have made important contributions to the work of the **China Council for International Cooperation on Environment and Development** (CCICED) which reports to Premier Li Keqiang, who had previously been responsible for its work. One such Canadian was **Dr. David Strangway**[32],

Dr. David Strangway. Credit: CBTO screenshot.

past president of the Canada Foundation of Innovation (which provides billions of dollars in funding to university and hospital research infrastructure in Canada), past President of the University of British Columbia, and the Founder of Quest University in British Columbia. Along with **Feng Zhijun**, Counsellor with China's State Council, Dr. Strangway co-chaired the Task Force on Innovation and Environmentally-friendly Society of the CCICED. In 2008, their report *Building an Environmentally-friendly Society through Innovation: Challenges and Choices – A National Environmental Action Plan* was submitted to China's State Council and then to Premier Wen Jiabao. This report was released at a time when China was poised to act on a range of decisions to reduce pollution, increase energy efficiency, and enhance the roles of its R&D institutions to contribute to innovation in China.[33] This is extraordinarily important work, and the late Dr. Strangway made a significant contribution, as have other Canadians including **Elizabeth Dowdeswell**, co-chair of CCICED's Task Force on Environment and Social Development in



Credit: Twitter: @LGLizDowdeswell

2012-13. Ms. Dowdeswell is Past President of the Council of Canadian Academies, and former Under Secretary General of the United Nations, and her appointment to the position of Lieutenant Governor of the Province of Ontario was announced in July 2014.[34] She is seen here with **Dr. Yin Li**, Governor of Sichuan Province.[35] As we now know, China has become an international leader in the Paris Climate Agreement and has made great strides in renewable energy and environmental science --- and Canadians played an important role in helping to develop China's policy capacity to that end.

Through the years, CIDA and IDRC sometimes played complementary roles. For example, IDRC supported some of the task forces of CCICED that CIDA had helped China to create. Similarly, IDRC created and nurtured in-house the International Network of Bamboo and Ratan and devolved INBAR in the late 1990s to become the first and still only international research intergovernmental organisation based in China, and CIDA provided support to INBAR some years after this devolution.[36] The last CIDA projects in China were completed in March 2014, as China was no longer viewed by the Canadian government as a "developing country", but IDRC continues to play an active role in China, although no longer as a recipient of substantial IDRC funding, but rather as a valued research partner.

3. DEEPENING THE ACADEMIC RESEARCH RELATIONSHIP

China STI experts Denis Simon and Cong Cao have observed that China, as an emerging global technological power, will have to rely on "the sustained development, deployment and mobilization of a high-quality, high-performance cohort of scientists, engineers, and R&D professionals who can position China at the cutting edge of global innovation and scientific advance".[37] Domestic industry is already demanding job-ready, innovative skills. This was evident in a 2012 Canada/China Academic Forum panel of executives of three Chinese aerospace companies who described the most important skill-sets to work in aerospace technology as the ability to think systematically, the ability to generate bold or innovative solutions, up to date knowledge (ability, speed, transformation), the ability to summarize and refine information, a thorough grasp of new technology, strong interpersonal communication skills, an awareness of their responsibilities, a willingness and ability to collaborate, the ability to be focussed and diligent, and a zero personal tolerance for errors and mistakes.[38] When challenged on the expectation of innovation without mistakes, the executive clarified that he expected no mistakes of the negligence variety, rather than related to innovation in processes or products. Clearly, there is an expectation that the Chinese graduates of the future will have to have all or most of these skills – a tall order in any society's industrial system. One way to acquire those skills is to train in other cultural systems at universities, colleges and institutes of technology around the world, and China has had this strategy for decades. In addition, many academic programs in western countries have co-op programs where students can get industrial experience along with their degree.

Since 1972, Canada has had student exchanges with China – primarily Chinese university students coming to Canada. In 1974, the **Canada/China Scholars' Exchange Program** was started by IDRC and the Social Sciences and Humanities Research Council (SSHRC). The Canada-China University Linkage Program was launched in the 1980s supporting 31 institutions that wished to work together. In the 1990s, CIDA created the **Special University Linkage Consolidation Program** supporting 11 linkage projects involving 25 Canadian and more than 200 Chinese universities, teaching hospitals and agencies. CIDA invested over $250 million in higher education in China since the earlier 1980s.[39] There are now more than 130,000 students to Canada from China in a given year, but fewer than 5,000 Canadian students going to China for study.[40] This is an imbalance that the government of Canada and Canadian universities are attempting to address.

There have also been many exchanges of professors in all disciplines over the decades. This has resulted in a very close research relationship between the two countries which provides a significant platform for ongoing collaborations on science and technology.

There are several examples which illustrate the scope of the S&T being developed by academic researchers in both countries working together:

- The University of Alberta and Tsinghua University (known as the MIT of China) have joined together to create the new Joint Research Centre for Future Energy and Environment for collaboration on energy, environment, climate change, renewable energy, advanced power systems, and energy transportation.[41]

- The University of Ottawa and the CAS University Shanghai Institute of Materia Medica (SIMM) have established a Joint Research Centre on Systems and Personalized Pharmacology on the medicinal properties of plants and the potential for development of new medications for diseases such as Ebola, TB, and HIV.[42]

- The Ottawa-Shanghai Joint School of Medicine is the first Sino-Canadian medical school as collaboration between the University of Ottawa and Jiao Tong University.[43]

- The University of British Columbia has partnered with Chongqing Medical University in the Canada/China Joint Centre for Translational Medical Research in Child Development and Alzheimer's disease, for which Canada Research Chair **Dr. Song Weihong** received China's highest honour for foreign experts – the Friendship Award.[44]

With each centre, there is a significant training element to educate students from both countries.

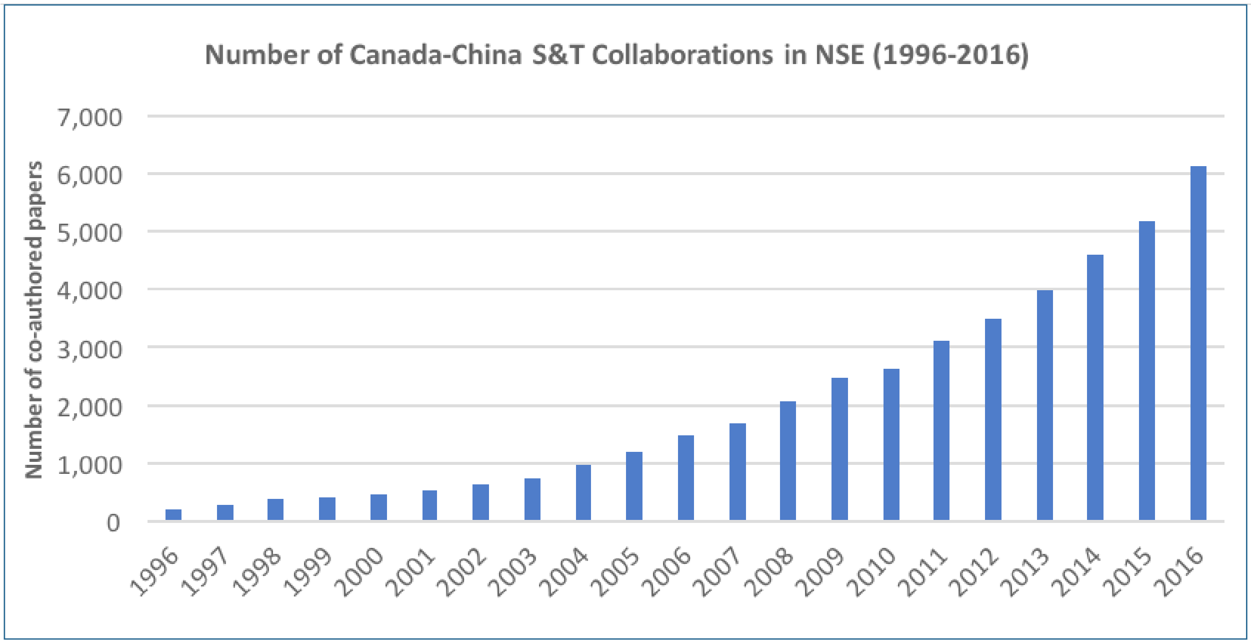
In addition, the enormous 1.52 million Chinese diaspora and Canadians of Chinese descent (of a total population of 35 million), including thousands of academic, government and industry researchers, as well as the extensive network of students will be a key advantage for Canada in deepening its collaborations with China. Indeed, in 2012 in the natural sciences and engineering (NSE) disciplines, in the flagship Discovery Grants of NSERC at $394 million per year, the top five most common names were all Chinese: 50 Chen's, 49 Wang's, 47 Li's, 43 Zhang's, and 36 Liu's. The most common Anglo-Saxon name was Smith, trailing at 30.[45] This demonstrates clearly that Chinese researchers and students coming to Canada will very often find Mandarin speaking colleagues on their research teams, making the cultural interaction that much easier.

Dr. Song Weihong receiving the Friendship Award.
Credit: https://www.youtube.com/watch?v=-CVbrEM_H9g

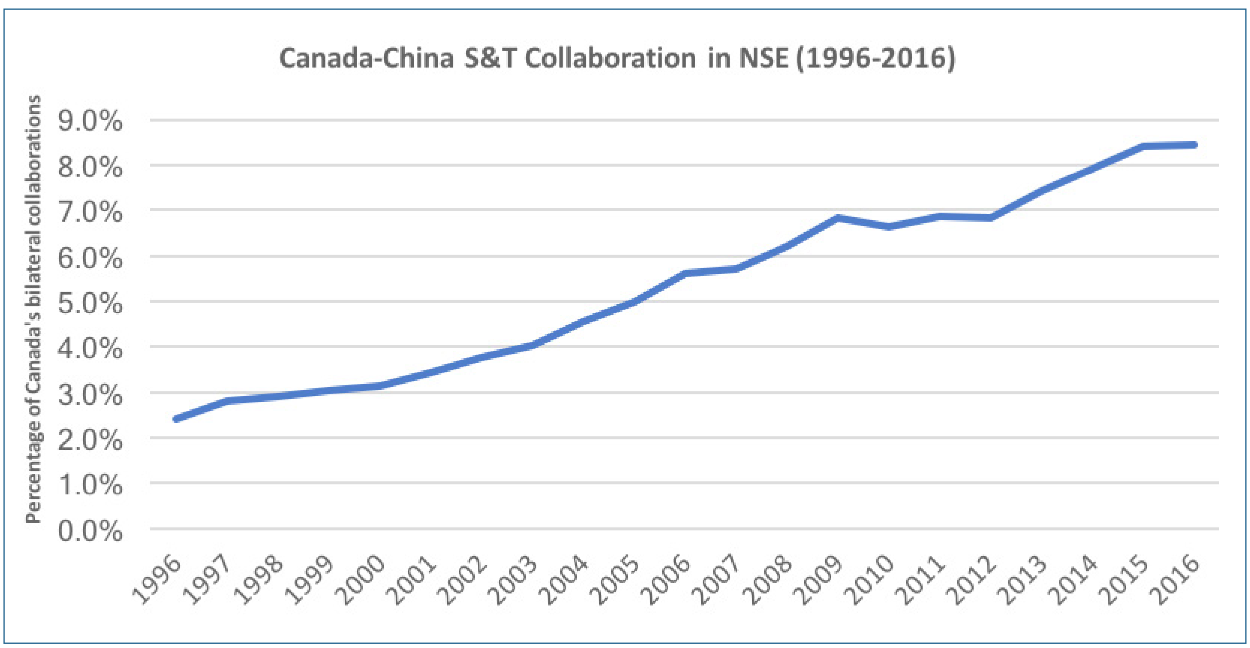
The number of bilateral collaborations in NSE has exploded since 1996, as can be seen from the bar chart on the following page.

Even as a percentage of Canada's overall bilateral collaborations, there is no question that China is now one of Canada's prime partners in research and development.

In Canada, education is provincial jurisdiction and consequently there is no national education department with leadership to undertake international strategies for collaboration with researchers in other countries. However, a number of proactive initiatives are fulfilling that function, at least in part. Global Affairs Canada is proactively engaged in international education collaboration and recruitment, having commissioned an independent panel to advise the government on Canada's International Education Strategy[46] as well as its



Source: Compiled by Science-Metrix from Web of Science (Clarivate Analytics)



Source: Compiled by Science-Metrix from Web of Science (Clarivate Analytics) continuing partnerships with China on innovation. In addition, Canadian universities themselves have collectively organized to engage with China. The Canada/China Academic Forum met in Edmonton in 2010, Chengdu in 2012, and then in 2014 held a substantive workshop in Harbin, to identify best practices and strategies for Dual Degrees at the doctoral level. The Forum included 27 Canadian and 40 Chinese universities with support from the China Scholarship Council, and these fora have proven very productive in developing new partnerships and identifying mechanisms that will allow both countries to deepen their research efforts and provide enriched training experiences for students. An even larger group of Canadian universities and colleges was scheduled to travel to China in October 2017 to advance Canada-China academic relations, organized by Universities-Canada, but this mission was postponed two weeks before departure due to overlap with China's 19th Communist Party Congress and it is hoped to reschedule the mission to a later date pending information from Chinese partners. At the core of this delegation is the U15, Canada's top 15 research universities.

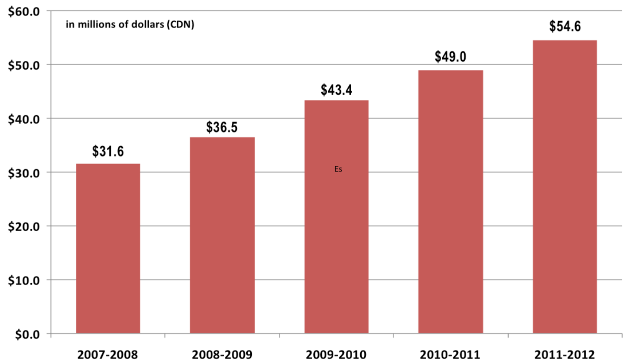
Canadian colleges are also working closely with China's institutes of technology for whom they have developed and implemented a leadership training program, and with whom they are initiating collaborative research.[47] Likewise, a Canadian organisation called Mitacs is building on its role in offering Globalink research scholarships in China, as well as funding students in Canadian universities to participate in research projects in companies in China.[48] The networks of researchers established through these initiatives will lead directly to joint Sino-Canadian innovations, and in the longer term will provide an expanding network for enriched collaborations in and between both countries.

The federal granting councils have been very active in funding international projects, for example, through the G-8 and the Belmont Forum, and all three councils are funding more and more projects every year that have partners in China. In 2012, statistics were compiled for the first time across all three granting councils for a keynote presentation by the author at the Chengdu Canada-China Academic Forum. On the following charts are the levels of funding from 2007 to 2012 for the Natural Sciences and Engineering Research Council (NSERC), the Social Sciences and Humanities Research Council (SSHRC), and the Canadian Institutes for Health Research (CIHR), tabulating the dollar figures for all the councils'-funded research projects involving at least one partner in China.[49] While the numbers are now somewhat dated, it is important to note that both the Canadians and Chinese at the Chengdu Forum were surprised and pleased that there was already so much bilateral collaboration taking place.

In addition, the Conference Board of Canada has launched a five year national Post-Secondary Education and Skills Initiative which will identify and initiate new ways that a cross-Canada strategy can benefit the private sector, particularly in attracting employees who meet international standards of excellence and are globally networked. The initiative will identify ways in which universities can offer students opportunities to develop these skills. The key leaders of the Board's initiative have active networks with China's government and academic organisations, and China is clearly a priority for international training, networking and benchmarking.[50]

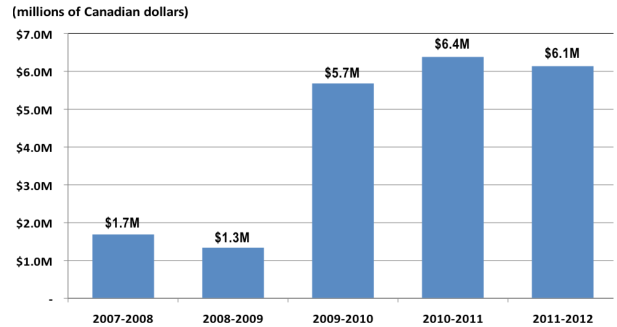
Over the past three years, China has invested massive amounts of funding to install world class research facilities across the country. University labs have been big beneficiaries of this investment, along with the Chinese Academy of Sciences. Canadian researchers should now begin to look at labs and facilities in China as a new venue for their research projects. For example, the Canadian Light Source (CLS) synchrotron has 19 beamlines with potential for 10 more – the Shanghai Synchrotron has 60, with potential for more.[51] Similarly, the Sudbury Neutrino Observatory (SNOLAB) is 2 km underground – the new Jinping Observatory in

NSERC Support for Projects with Chinese Participants



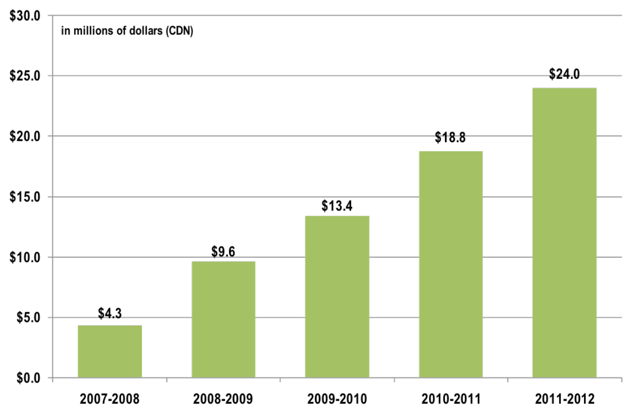
Source: Statistics Office, NSERC

SSHRC Support for Projects with Chinese Participants



Source: Statistics Office, SSHRC

CIHR Support for Projects with Chinese Participants



Source: Statistics Office, CIHR

Szechuan is 2.4 km underground. China is going bigger, deeper, and better than any Western country with respect to the labs it is building and equipping. This is an opportunity for Canada to collaborate with China and take advantage of their top-of-the-line equipment for our scientists to use. Big Science projects such of these are generally characterized by such cooperation, as can be seen by the ongoing design and operations advice being provided to the Director of Jinping by the Executive Director of SNOLAB. The culture of collaboration runs through all Big Science projects, whose aim is to advance the common cause of understanding the universe. Scientists from many countries are usually involved in each Big Science project. From August to October of 2017, the Chinese Academy of Science and Technology for Development (CASTED) sent one of their scientists to Canada to research and report on the governance of our Big Science labs, as China prepares to improve the operations of its labs to world-class levels.[52]

On the research policy front, Canada and China together took an important leadership role in 2014, co-chairing the Global Forum of Research Councils (GFRC) in Beijing at which 60 heads of research granting councils from around the world engaged in substantive policy discussion of international measures for facilitating international research, including open access for publications and supporting the next generation of researchers. Canada subsequently hosted the May 2017 meeting of the GRC in Ottawa.

4. SINO-CANADIAN INDUSTRY RELATIONS IN TECHNOLOGY DEVELOPMENT

While Canada has much technology of interest to China, particularly in the energy and bio-medical sectors, Canada's overall track record in business investment in R&D and commercialisation is still lagging in comparison to those of other countries. Indeed, in China's sixth annual National Innovation Index published in 2015, Canada barely figures for reference in China's comparisons with leading innovative nations. The Index notes that "… Canada, Finland, Spain and Greece have slowed in R&D expenditure growth" and just a passing reference that China is ranked 14th in innovation performance and is "… already higher than several developed countries such as Sweden, the Netherlands, Austria, Canada and Italy and far ahead of other developing countries".[53] The U.S., Japan, Republic of Korea, Germany, France and Israel are among the countries against which China benchmarks its own performance across many factors of innovation. As China continues with its plan to become the world's foremost economic superpower, fuelled by innovation, there is more and more that Canada can learn from China. With its international technology companies, investments in R&D (with Gross Expenditure on RD / GDP rate at 2.02%[54] having passed Canada's GERD/GDP in 2011), and investment in its highly qualified personnel, China is becoming the nation with which many other countries want to partner.

A paper by Dr. Chen Yong, of the Department of Science and Technology of Zhejiang Province illustrates the assessment of Canada's innovation system by China's policy analysts. Dr. Chen reviewed the literature in Canada to conclude that Canada has strong fundamentals in innovation, high quality research, high levels of investment in R&D and higher education, strong student performance in science and mathematics, success in attracting and retaining highly skilled workers, and innovation capacity distributed across the country. Key sectors such as energy, environment, life sciences, aerospace and automotive are strong within Canada, and international collaboration with China and other countries, notably the US, are also strong. However, Dr. Chen goes on to suggest that the innovative capacity of Canadian enterprises is still relatively weak, and cooperation between industry and academia is not as close as it should be. He also suggests that Canada lacks strong initiatives for encouraging enterprises to increase their investment so that industry will invest more in innovation. He concludes that China can learn from Canada in the evaluation of innovation development and policies, in areas to improve the innovation system, and in the commercialisation of innovative products, by focussing cooperation with Canada in the areas of energy, environment, life sciences, agriculture, ICT and aerospace. For someone on the other side of the planet, Dr. Chen has assessed Canada's track record in innovation fairly accurately.

One explanation for Canada's track record on business innovation is provided in a report by the Council of Canadian Academies, which identified Canada's special relationship with the U.S. economy through the North America Free Trade Agreement as providing the protection from economic stresses and "small catastrophes" that can propel companies into a strategy of intense innovation. In the comfortable niche of Canadian businesses,

> … Aggregate profitability ratios have matched or exceeded those of the United States. With little motivation to change a successful formula, many firms have settled into a 'low-innovation equilibrium' that has conditioned business habits and ambitions, and shaped the predominant business culture in Canada.[56]

With an economy so closely tied to that of the U.S., Canadian business and government leaders pay close attention when Sino-American relations in science and technology are under stress. Such has been the case in recent years around issues such as theft of intellectual property of U.S. technology as well as cyber-attacks and spying -- concerns shared by some in Canada for Canadian technology as well. In particular, Congressional distrust of China has had direct impact through its "… prohibition on expenditure of funds by the Executive Branch on U.S.-China co-operation in space and in science more broadly, which denies the U.S. government a potential tool for reducing strategic distrust with China".[57]

Consequent omission of China from some scientific meetings in the U.S. is both restriction of access to that which others will have, as well as a loss of face for a nation that is rising in the ranks in innovation, and has negatively impacted the relationship. This rough patch in relations between the U.S. and China has prompted serious concern north of the Canada/U.S. border. As a former Canadian Ambassador to China put it, "It is never a good thing for Canada when U.S. relations with China are poor; our companies can be directly affected, since they can be tied to the U.S. through legislation (for example through conditions of ITARs); we have to work closely with U.S. officials to understand the ways in which Canadian business might be affected, and what we can do to minimize impacts on them."[58]

There is not sufficient space in this overview of Canada/China relations in science and technology to include the many industry-related technology collaborations over the years. Suffice to say, there have been decades of exchanges between companies in China and those in Canada since the launch of Reform and Opening in 1978. As already mentioned, agriculture has been a critical sector over the years for both Canadian and Chinese companies, as well as biotechnology and ICT (particularly in the years before Nortel's demise). However, the subject of energy is so pivotal to both countries now that it merits particular, if brief, attention.

Over the ten years of the Harper Conservative government, Ministers were fond of saying that Canada is an energy superpower, as the second biggest producer of uranium in the world, third largest producer of hydroelectricity, the third-largest producer of natural gas, vast oil and gas reserves, and advanced nuclear technology.[59] Under the new Liberal Government, Ministers have toned down the 'superpower' rhetoric and are putting more focus on clean energy technology. For example, the March 2017 Budget cited Canada's commitment under Mission Innovation to double the country's 2014-15 baseline expenditures of $387M for clean energy and clean technology research, development and demonstration by 2020, with Budget 2017 investing *inter alia* in new green infrastructure and clean technology.[60] China too is a leading producer of energy and to meet its own demand it needs what can be produced domestically and bring in the balance as imports. And China has been making astounding investments in renewable and energy efficient technologies; in fact, in all subsectors of energy Canada and China have much in common and stand to benefit significantly through increased collaboration in technology development.

Canadian companies have engaged in the China market primarily for the significant potential trade benefits, but when Canadian technology is involved, China reaps benefits too. For example, in the 1990s, GE Hydro Canada of Lachine, Quebec won one of the large turbine equipment orders for the then new Three Gorges Dam. In fact, GE was only one of six foreign companies that were awarded contracts for Three Gorges, giving China access to advanced technology from around the world.

Over the decades, Canadian companies opened up markets in China through the introduction of advanced technologies. Until its unfortunate demise, **Nortel** was a major force in China and helped the country leapfrog over landlines and telephone poles to provide cellphone service across the countryside. Since then, China has sought to extend the leapfrogging approach (or "frog leaping" we sometimes hear) across other technology sectors. **Bombardier** is another Canadian company that has introduced advanced technology into China – in both the high-speed rail[61] and aircraft sectors. Bombardier has had direct sales as well as partnerships with Chinese companies. At the same time, however, it has stimulated China to advance its own corporations in these sectors, sometimes in competition with Bombardier. As an example, on May 11, 2017 it was announced that China's CRRC Corp[62] had bid successfully for a contract in Montreal – Bombardier's front yard. They will provide 24 double-decker train cars to Montreal's regional commuter-rail service for just $69M – far under the budgeted $103M.[63] Such is the international trading environment for technology companies. Bombardier has three joint ventures with CRRC Corp and no doubt this contract has been a subject of discussion since it was announced.

With an eye to the combined challenges of urbanisation and the environment, energy

Bombardier Rail Vehicles Production Site in Changchun, China. Credit: Bombardier.

conservation, energy efficiency, and renewable energy technologies are taking on a high priority for China, and Canadian companies and research labs are very active with China on these technology platforms. In renewable energy, the **National Research Council** in Canada is working with **Jiangsu Aoxin New Energy Automobile Company** to commercialize the technologies of Canadian companies for electric vehicles, recognizing Canada's leadership in fuel cell and battery technologies.[64] **Ballard Power Systems** of Burnaby B.C. has had pilots and some sales in China for many years and sees potential markets for its buses and autos in the context of China's move into fuel-efficient vehicles, as well as other product lines. For example, Ballard has provided back-up power systems for telecommunication systems in China through a partnership with **Azure Hydrogen**[65], and Ballard ran fuel cell buses at the 2008 Olympics in Beijing. It now has a joint venture with **Guangdong Nation Synergy Hydrogen Power Technology** for a factory for fuel cell systems.[66] Similarly **Conserval** solar wall technology was used to build the Athletes' Centre at the Athletes' Village, and now that building serves as the kindergarten for the surrounding apartment complexes. Conserval now has a joint venture with China's **SunRain**. **Westport Innovations** is another Canadian company that is currently building energy technology relationships in China, and it now has a joint venture with **Weichai Power and Hong Kong Peterson**. For more than twenty-five years, Canadian companies in clean energy technologies such as solar energy and Super E energy efficient homes

A portion of the new Foshan fuel-cell bus fleet.
Credit: Ballard news release.

have been supported in their collaborations with Chinese companies by Natural Resources Canada's **CanmetENERGY** clean energy technology labs. Two Candu nuclear plants were built in Qinshan in the early 2000's, and hoping for more, **Candu Energy Inc** now has a joint venture with **China National Nuclear Corporation** (CNNC) to build the Advanced Fuel Candu Reactors in China as well as to sell it to third countries. With the threat in 2007 of a shortage of uranium used as fuel in reactors, Atomic Energy of Canada Ltd and the Nuclear Power Institute of China signed an MOU for collaborative R&D in nuclear technology.[67] With the publication of the 2017 Global Cleantech Innovation Index, other nations can see from Canada's #4 ranking that our country is a top source of clean technology.[68] China in particular will take notice, as cleantech is one of its high priorities as it struggles to get on top of environment and energy pressures.

In oil and gas, Canadian company **Phase Separation Solutions** has been very successful in offering advanced clean-up and treatment technologies for oil field waste and site remediation. In fewer than four years, it established itself in China as a Canadian-Chinese company with an aggressive growth strategy.[69] But the technology story in oil and gas goes far beyond trade and collaborative technology development opportunities into complex investments being made by China in Canadian companies, each carrying technology benefits. Starting in 2005, Chinese companies including State Owned Enterprises (SOEs) started buying blocks of shares in small and medium sized companies (16.69% of **MEG Energy** by **CNOOC** and then 40% of **Northern Lights Oil Sands** by **Sinopec**), then buying the full value of small and medium sized companies (100% of Nations Energy by CITIC Group), a large stake in the oilsands (Sinopec's $4.65 billion purchase **ConocoPhillips'** 9.03% stake in **Syncrude**'s Oil Sands Project), culminating in CNOOC's purchase in June 2012 of **Nexen** for $15.1 billion. The Nexen deal went through the Government of Canada's investment review process successfully, but the Government subsequently brought in new guidelines indicating that SOE acquisitions will, in the future, be required to demonstrate, through a series of factors, the net benefit to Canada in order to be approved.[70]

With each of these purchases, China acquired important oil and gas technology, as well as the related expertise in how Canada manages large resource extraction facilities. While the drop in the price of oil resulted in some losses for China, the long term intention of both countries is to seek out new markets in China for Canada's oil and gas resources. Virtually all Canadian collaborations with China that relate to the energy industry have a significant technology component.

The government of Prime Minister Justin Trudeau has indicated that it will provide for some degree of flexibility with SOE takeovers. In fact, it has recently approved several controversial investments including Anbang's takeover of Canadian retirement home chain **Cedar Tree**[71], Hytera Communications' takeover of satellite company **Norsat**, and **O-Net Communications** purchase of **ITF Technologies** without full national security reviews. Regarding these last two high tech firms, Canadian public opinion is now strongly opposed to the sale of these companies, which were given the green light by the federal government --- but despite this, there is still a slight majority of Canadians favouring negotiation of a free trade agreement with China.[72] As discussions move from exploratory talks to FTA negotiations, assuming that happens, it will be interesting and important to watch the technology dimensions of the relations as there may be a spill-over effect in the negotiations.

Finally, Canadian and Chinese start-up companies – often the technology companies of the future – are beginning to find new linkages by way of incubators and accelerators in both countries. Incubators in China are now getting a strong influx of government funds to nurture start-ups, and they are increasingly partnering with incubators in the west, especially in Silicon Valley. In Canada, Invest Ottawa has a very strong partnership with Zhongguancun Development Group to nurture Canadian start-ups and introduce them to Chinese partners when they are ready, and companies from Velocity incubator in Waterloo have spent time at HAX accelerator in Shenzhen. Even makerspaces are finding synergies, with ARCHEloft in Calgary linking with SEEED in Shenzhen. More of these exchanges and partnerships can be expected in the coming years.[73]

5. GOVERNMENT TO GOVERNMENT RELATIONS IN SCIENCE AND TECHNOLOGY

With the Reform and Opening policy announced by **Deng Xiaoping** in 1978, China started to open up to science and technology from the west. In 1979, on a cross-China tour of members of the University of Toronto Alumni, the author was pleased and impressed to see that the libraries of universities, colleges and teaching hospitals contained the latest science journals as the country made efforts to catch up to what had been happening in the rest of the world of science and technology.

Throughout the 1980s, 1990s and 2000s, the Government of China sent delegations to Ottawa and other regions of Canada to learn about Canadian programs and best practices in science and technology development. [For organigrams of the Canadian and Chinese S&T government structures, see Appendix B] These delegations usually focussed on a particular area of science such as Agriculture or Geoscience, and Canadian officials, on behalf of their departments, sometimes enter into one to one memoranda of understanding (MOU) with their Chinese ministry counterpart in order to undertake ongoing collaboration. Examples of MOUs include:

- 1980 MOU between China's Ministers of Agriculture and State Farms and Land Reclamation, and Canada's Minister of Agriculture;
- 1986 MOU between the China Meteorological Administration and the Meteorological Service of Canada;
- 1994 MOU between the Chinese Academy of Sciences' (CAS) Institute of Remote Sensing Applications, and Natural Resources Canada's (NRCan) Centre for Remote Sensing;
- 2001 MOU between the National Development Reform Commission of China, and NRCan for cooperation in the field of energy;
- 2007 MOU between China's State Oceanic Administration, and Fisheries and Oceans Canada;
- 2014 MOU between the South China United Vaccine Institute, and the Canadian Vaccine and Infectious Disease Organisation, among others;
- 2016 Joint Declaration on Clean Technology Cooperation between the Minister of Innovation, Science and Economic Development, and the Minister of Natural Resources with China's Vice Minister of the Ministry of Science and Technology.

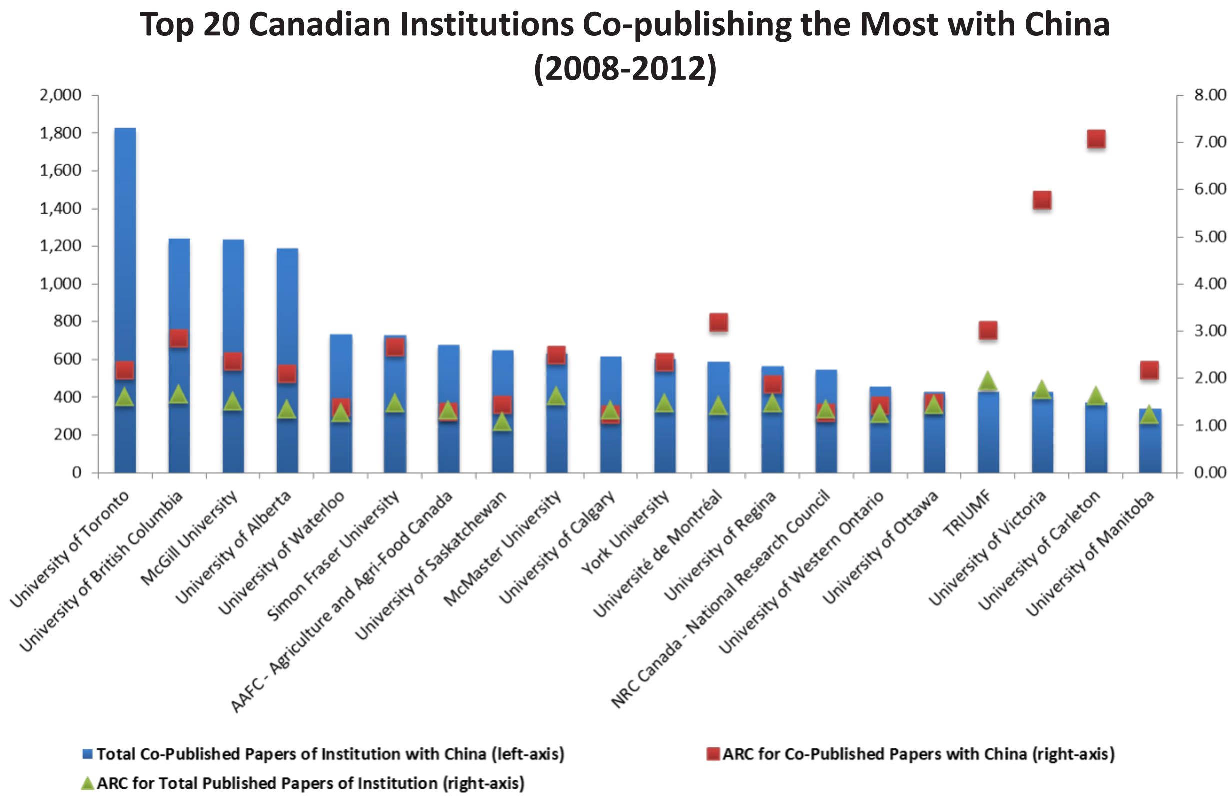
These MOUs, and others, have been highly successful in deepening the relationships of collaboration, and as they are normally five years in duration, some of those listed above have been renewed multiple times.

In addition to wanting to learn more about Canada's science and technology policies and programs, China was interested in learning about Canada's departmental governance and management techniques. Such was the case in 1998 when China's Minister of Water Resources proposed to house an Industry Canada executive in his Ministry for a two year period as a senior policy advisor to introduce team approaches to managing initiatives. Canada did not take up the offer, which was subsequently accepted by Craven Crowell, former Chairman of the Tennessee Valley Authority. But the Canadian government was open to a secondment to give Chinese officials direct experience in the management approach of a western government department. In 1999, **Industry Canada** hosted a one-year secondment of two mid-level officials of the **Ministry of Water Resources** to Industry Canada's Manufacturing and Processing Technologies Branch, and Environmental Technologies Branch, to learn about Canadian techniques of team management and how Canada was addressing industry sector technology challenges.[74]

Furthermore, requests came as early as the late 1970s from a number of countries including China's then **State Science and Technology Commission** (later to become the Ministry of Science and Technology) to sign a high level agreement with Canada on science and technology. As Richard P. Suttmeier observed in 1980, as China was making such overtures to a number of countries, "Such cooperation would give China access to an expanded range of scientific and technical information, it could serve to set the pace or be the point of reference for Chinese research and development in certain fields, and it could ease the financial burden of an ambitious research and development program through cost-sharing arrangements".[75] Canada's S&T policy department at that time was the **Ministry of State for Science and Technology** (MOSST) which has since merged with other departments and agencies to become Industry Canada, and more recently **Innovation, Science and Economic Development** (ISED).

In 1982, the question of bilateral agreements in S&T (government to government legally binding in international law) was referred to the Cabinet of **Prime Minister Pierre Trudeau**. The ministerial view was that the government already had general agreements on S&T with other countries (Germany, France, and Japan) under which there was no dedicated central funding available in Canada; the lack of Canadian central S&T funding to match the partner country funding was causing some difficulties in the relationships. Other countries, including China, saw these agreements as non-binding MOUs, but Canada viewed MOUs as treaties and therefore was concerned that if there were no funding to implement the agreement, they would be abrogating a signed agreement. Since there was no appetite at the Department of Finance to establish dedicated pots of central funding for bilateral S&T activities, why have another such agreement? Therefore, Cabinet decided that Canada should not enter into any further government-to-government S&T agreements unless there were extenuating circumstances. The Cabinet decision was the touchstone for Canadian governments for decades after, and countries that requested such an agreement always hit a stone wall. Instead, MOSST and the then **Department of Foreign Affairs and International Trade** facilitated meetings of visiting Chinese delegations with key universities, as well as line departments and agencies such as Agriculture Canada and the National Research Council.[76] This strategy, at least in part, explains the early and continuing strength of the research relationship across universities and with those two agencies in particular. Among the top 20 Canadian institutions co-publishing with China in the period 2008-2012 (the last years for which numbers are available), most were universities but #7 is **Agriculture and Agri-Food Canada**, and #14 is the **NRC**.[77]

The delegations that came from China on broader issues of science and technology were very self-effacing, and emphasized that Chinese officials had come to learn from Canadian experience. They were not very



Source: Computed by Science-Metrix using Web of Science data (Thomson Reuters)

forthcoming about what their own ministries were introducing as initiatives, nor were many Canadian officials particularly curious about what was happening in China, as it was felt that China still had a lot of catching up to do. Presentations and discussion were usually very high level, often with consecutive translation that further detracted from a substantive exchange and cut by half the amount of territory that could be covered in meetings. Throughout these years Canada maintained a network of science and technology counsellors in Canadian Embassies to identify opportunities for collaboration in countries in Europe, Japan, and of course the U.S. – but never in China. At its height in the late 1980s there were seven S&T counsellors and two Space counsellors at posts abroad. However, the 1990s saw a series of budget cuts that over the years resulted in a reduction of S&T counsellors so that today there are just two – in Washington and Berlin. This impeded the department's ability to engage on S&T matters with other governments and to support the China S&T engagement of other stakeholders. Only now is there a move to reinforce that function in the department.

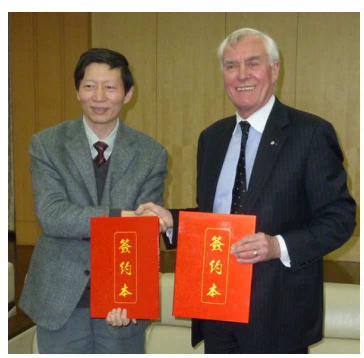
China was a member of international organisations such as the **Asia Pacific Economic Cooperation** (APEC) and the **United Nations Educational, Scientific and Cultural Organization** (UNESCO), and Canadian officials had opportunities to engage with officials from China in those contexts, including when meetings were hosted in China.[78] These occasions provided a window through which Canadians could glimpse the state of China's technology development, and brought science and technology best practices together from all over the world, to the benefit of China's organisations.

The real focus of attention for Canada through the late 1980s, 1990s and 2000s was the enormous opportunity for trade. In April 1987, **Prime Minister Brian Mulroney**'s Government quietly announced a 'China Strategy' that had been developed by government officials through extensive consultations with China experts across the country. However, according to B. Michael Frolic, it was barely noticed by the Canadian public. The Strategy focused on improving trade in the "China market" by a "Canada Inc." approach. The document observed that: "China's modern history has been marked by a realization that it cannot become a major power without accepting foreign technology and management techniques, and also by a deeply xenophobic reaction to the penetration of western ideas and philosophy". The Strategy clearly saw the importance of CIDA's role in building on "… China's open-door policy designed to acquire Western technology and skills … in jointly identified sectors where Canadian expertise meets Chinese priorities, for example, agriculture, energy, and forestry, as well as telecommunications and transportation"; and for the Canadian private sector, "… government support should be directed in a selective fashion to those Canadian companies that have products, technology, and expertise that respond to China's priority requirements, and the 'staying power' to weather both economic 'ups and downs', and the slow approval process".[79] However, no one expected the "down" that came two years later in the wake of Tiananmen in 1989. The Strategy was subsumed for a number of years by human rights concerns brought to China files of the Mulroney government, and despite numerous initiatives to have the Cabinets of successive governments approve a new China Strategy or an 'Asia Strategy', this was the first and also the last public strategy.

But despite the lack of a formally documented approach, in 1994 **Prime Minister Jean Chretien** put a new trade focus on China, and he began what came to be frequent "Team Canada" missions to China of business leaders and sometimes provincial Premiers, which created a growing 'Canada-brand' impact. Team Canada missions were very effective in China, with hundreds of trade deals signed and huge goodwill built up. This new, warmer relationship was demonstrated at a 1998 Canada/China Business Council dinner of hundreds of Canadian CEOs and university presidents at the Great Hall of the People where **Premier Zhu Rongji** departed from his prepared remarks to say that "Canada is our best friend in the whole world!"[80]

Prime Minister Jean Chretien and Premier Zhu Rongji.

That made for a hard act to follow, but when he won the leadership of the Liberal Party in 2003 and became **Prime Minister, Paul Martin** put a new focus on science, technology and innovation broadly, and also gave China high priority in his Government's foreign relations. At that time, the Department of Foreign Affairs and International Trade was developing its policies in relation to the BRIC countries (Brazil, Russia, India and China; later South Africa was added to create BRICS), and was looking for ways in which its international initiatives could contribute to the government's innovation/commercialisation agenda. A joint Canada-China Strategic Working Group was established to identify ways to enhance collaboration in areas of mutual interest. Prime Minister Martin also appointed **Dr. Arthur Carty**, then President of the National Research Council, as Canada's first



Dr. Carty with Dr. X. Zhu, President of Soochow University. Credit: University of Waterloo.

National Science Advisor. Dr. Carty reported directly to the Prime Minister, and took the initiative to propose funding for S&T collaboration with China and India. In the February 2005 Budget, $20 million over five years was earmarked for international S&T. The Chinese Embassy presented a draft agreement, but there was a delay until the Canadian government had the policy, mechanism and funding in place.

After a meeting January 20, 2005 in Beijing between Prime Minister Martin and **Premier Wen Jiabao**, the leaders stated in their Joint Declaration that "Canada and China are committed to strengthening growth and reducing poverty through policies designed to expand trade, investment and innovation in an increasingly integrated global economy" and that "we will also strengthen our cooperation through an ambitious program of technical assistance, to support China's full and active participation in the World Trade Organisation". In addition, the statement said that the leaders were resolved to address the problem of global warming in light of their shared commitment to sustainable development and balanced growth.[81]

Prime Minister Paul Martin and President Hu Jintao.
Credit: www.chinadaily.com.

Later that year, in September 2005 in Ottawa, Prime Minister Martin and **President Hu Jintao** announced a "strategic partnership" between their two countries.[82] Under that partnership, they established a Strategic Working Group, still in place twelve years later, to discuss cross-cutting economic and political priorities. This Working Group brings together the Deputy Ministers of Foreign Affairs, International Trade and Natural Resources (again, an indication of the importance of energy to the relationship), with China's Vice Ministers of Foreign Affairs, Commerce, and the National Development and Reform Commission. This is in addition to the annual meetings of the Joint Economic and Trade Commission, a Deputy Minister / Vice-Minister level forum on trade and investment issues. At the September 2005 meeting the leaders in their *Declaration on Science and Technology Cooperation* struck a high level Canada-China Expert Study Team to advice on "Complementarities in Science and Technology". Co-chaired by senior officials of Canada's National Research Council and China's Ministry of Science and Technology (MOST) and including two academic and industry representatives from each country, the Expert Study Team considered sector priorities and mechanisms for S&T cooperation.

In October 2005, the Canadian Cabinet approved the terms of the $20 million in funding for international S&T partnerships with China, India, Brazil and Israel under the banner "**International S&T Partnerships Program** (ISTPP)". In addition, due to the extenuating circumstances of available funding, Cabinet approved the negotiation of S&T Agreements with India, China and Brazil and approved the renewal an S&T Agreement with Israel. The objectives of the Program were described as:

- encourage domestic competitiveness through the transfer of technology and knowledge resulting from international science and technology partnerships;
- foster international science and technology partnerships and collaborative research;
- accelerate the commercialization of R&D that would benefit Canada, through international partnerships with a focus on small and medium-sized enterprises;
- access international technologies for Canadian enterprises;

- promote Canadian R&D capacity and Canada as a destination for foreign technology-based investments; and,
- strengthen overall bilateral science and technology relations.[83]

When divided among four countries over five years, $20 million was a fairly small amount of funding, but it was expected that it would be catalytic, and the collaborations would expand from there. The Department of Foreign Affairs and International Trade (DFAIT) was not equipped to manage a peer review process itself. Therefore, taking as its model a successful S&T collaboration mechanism with Israel, which had been established in 1995, Cabinet agreed that the government would fund a new arms-length agency that could implement the peer review process for high priority projects in new and emerging areas of S&T collaboration. The key issue of ownership of the related intellectual property was to be determined by the project parties prior to the start of each project. In December 2005, the funding was approved in Parliament and the department started the competition process for the organisation to deliver the new program.[84]

In January 2006, Prime Minister Martin's Liberal Party lost a national election to the Conservative Party, and **Prime Minister Stephen Harper** took office on February 6, 2006. Many noted a cooling of the relationship with China during the first three years of the Harper mandate. The party came to office with a philosophical foundation that deplored communism and cited democracy, religious freedom and human rights among their strongest foreign policy touchstones. As remarked by Paul Evans, among others, this moralism led to a China policy built on "cool politics, warm economics". The Prime Minister declined the invitation to attend the 2008 Olympics in Beijing and delayed visiting China until December 2009, when **Premier Wen Jiabao** reproached him for not visiting earlier.[85] During this period, Minister of Foreign Affairs Peter McKay and other senior officials stated publicly that they

Premier Wen Jiabao and Prime Minister Stephen Harper. Credit: www.ledevoir.com.

were very concerned about the level of Chinese espionage in Canada, while China's track record on human rights was profiled in the deliberations of a parliamentary sub-committee.[86] However, following 2009 there was a recalibration of factors; while these concerns were still very much part of the Government's approach to its broad foreign policy, there was also a more significant focus on the economic and trade relationship – particularly in the Conservative Government's Global Commerce Strategy and the Global Markets Action Plan which featured technology and talent as important reasons for partnering with China among others.[87]

Despite the cooling of the relationship in the early years of the Harper Government, the momentum of the Canada-China science and technology discussions carried on and the Expert Study Team for the Complementarities analysis conducted extensive consultations with academic and industry leaders in both countries. In 2006, the Expert Team presented its report and recommended four priority areas for cooperation: **energy** and **environment** which they noted are inter-related; and **health/life sciences/ biotechnology** and **agriculture foods/bio-products** also noted as inter-related. The reasons cited for this selection were current capacities and existing collaborations in both countries, and the degree and nature of economic complementarities. The Expert Team saw areas such as ICT and nanotechnology as enabling other sectors. While they saw the agriculture sector as already having had decades of previous collaboration, they suggested that a new energy subsector, such as electric vehicles would require workshops and exchanges to initiate collaboration. The Committee was also clear that the four priority areas should not preclude future consideration of S&T collaboration in other sectors. In addition, the Committee recommended the inclusion of small and medium-sized enterprises (SMEs) in the collaborations, to continue to build linkages and partnerships, to develop young researchers, and to collaborate on joint S&T infrastructure such as virtual and physical laboratories. Further work was also encouraged to address intellectual property challenges and to identify appropriate criteria and mechanisms for measuring progress.[88] (A broader Canada/China Economic Complementarities study on trade and investment potential was completed in 2012 and focussed on an industry sector approach rather than covering the areas of the 2006 S&T Study a second time.)[89]

Also in 2006, the competition for the organisation to deliver on the International S&T Partnerships Program was completed. The winning group was the agency that, until that time, had been delivering the agreement with Israel. The President of the new larger arms-length not-for profit organisation decided to adopt the name "**International S&T Partnerships Canada** (ISTPCanada)". (Later it was found that there was some understandable confusion on the part of Chinese partners that this non-governmental organisation delivering a government program by the same name was not itself a government agency.) It was funded by the government to manage the peer-review project selection process, not only for China but also for the Government's agreements with Brazil and India. The partnership with Israel was being funded by the ISTPP through the Canada-Israel Industrial Research and Development Foundation (CIIRDF). Officials were then able to quickly negotiate agreements with each of China, India and Brazil, and a renewal of the agreement with Israel.[90]

With respect to China, DFAIT and MOST agreed quickly to the terms and conditions. Project proposals would require at least one company and one university in Canada, and one or the other in China. That is a fairly complex requirement to start with for an R&D proposal, particularly ensuring that intellectual property agreements are clearly established before the project begins. In China, the project review is handled directly by MOST for bilateral cooperation programs, such as the one with Canada under the Joint Committee. It is a two-stage selection mechanism: the first stage is a strategic review in which an expert panel of MOST reviews the proposals on target/objectives, tasks and feasibility based on the national strategy, and provides advice as to whether the project should go forward; the second stage is a technical review, whereby a different panel reviews the concrete application proposals and their technical indicators, and provides advice as to its technical feasibility. Then MOST comprehensively considers the review results in the context of the national S&T development strategy and policy requirements, determines the selected projects, and commissions the relevant agencies to carry out the budget evaluation. MOST reports to the Ministry of Finance on the budget suggestions of the projects based on the Budget evaluation results, and the Ministry of Finance normally approves the funding based on the detailed review process, and the projects can go forward.

For China, the ISTPCanada arms-length (i.e. not government controlled) peer reviewed selection process (modelled on the Canadian granting councils' process) was something they did not favour. Officials of MOST and the Chinese Embassy in Ottawa voiced their objections in pointed, though diplomatic, language. However, DFAIT was firm that this was the process it was going to use, and China accepted that. Projects were funded at a Canadian announced amount that covered the Canadian companies and university researchers, and China covered a proportional amount for their own companies and researchers (not necessarily dollar for dollar since costs of the research are often not as high in China).

6. CANADA-CHINA AGREEMENT ON SCIENCE AND TECHNOLOGY

On January 16, 2007, Canada's **Minister of International Trade David Emerson** and China's **Minister of Science and Technology Xu Guanhua** signed the *Agreement for Science and Technological Cooperation between the Government of Canada and the Government of the People's Republic of China* to guide the two countries' science and technology relations for future years. (The Agreement is available in Annex C for ease of reference.) For Canada it was important that this was not just an MOU signed by a single department. Rather, it is one of the only government-wide treaties that Canada has with China, next to the Canada-China Foreign Investment Promotion and Protection Agreement (FIPA) which was ratified by Canada to come into effect October 1, 2014. The S&T Agreement has been managed through the Department of Foreign Affairs, Trade and Development, now **Global Affairs Canada** (**GAC**), and it can coordinate and commit federal departments or agencies. Indeed, some of the earlier departmental MOUs with China have now been brought into conformance by referring to the S&T Agreement, and future Canadian S&T-related MOUs will refer to it as well, thereby having the force of a treaty behind the terms that they have signed. For China, it is its 100th intergovernmental science and technology agreement; it is focussed on MOST's activities, and can link with other Ministries but does not bind them.[91]

The common objectives announced at the time of the signing were: increasing the international competitiveness of our companies; innovation in addressing domestic and global challenges; and commercialisation of technology resulting from R&D partnerships. To implement the Agreement, the Ministers proposed to establish a funded initiative for bilateral cooperation in science, technology, innovation and commercialisation. The two Ministers also identified the areas of focus which came from the Complementarities Study as mentioned above, and these mapped well with Canada's S&T Strategy which came out the same year[92]: life sciences, energy and environment, information and communication technologies. To these sectors, the Ministers added agriculture.

a) Governance

The Ministers established a Canada-China Joint Committee (CCJC) to steer the decision-making on the joint funds and to set priorities for the research. The co-chair for China has been Vice Minister of MOST, now **Wang Zhigang** who is also Party Secretary for MOST. For Canada the co-chair for the first three years was **Dr. Pierre Coulombe**, President of the National Research Council[93]; with the retirement of Dr. Coulombe in 2010, the co-chair role was accepted by **Dr. Alain Beaudet**, President of the Canadian Institutes for Health Research. With his departure from government in 2017, he will soon be replaced on the Canadian side. There are six other members of

2010 CCJC meeting in Beijing.

the Committee. At the outset of the Committee, Canada thought it important that its members represent industry (Nortel and then Bombardier), universities (University of Montreal and then University of British Columbia) and government (NRCan and NSERC).[94] Chinese officials had some concern about including private sector and academic members on the Committee --- they usually prefer to work government to government. However, they made a real effort to mirror that model with Deputy Director Generals from appropriate offices of MOST initially, and with representatives such as the Vice President of ZTE Corporation and the Dean of Computer S&T at Tsinghua University. In 2017 however, the CCJC is undergoing a reset: a Canadian co-chair will soon be named, likely at the Deputy Minister level, and they will in turn confirm the other Canadian members – likely senior government officials, with additional advisory roles for industry and academia as appropriate.

b) Priority Sectors

Since the first meeting of the Joint Committee May 28, 2007 in Ottawa, six meetings have been held. The first meeting focussed on validating the Complementarities Study and establishing the processes and sector groups: agriculture, energy, environment, health/biosciences. In addition, at this first meeting, ICT was added to reflect Canada's domestic S&T Strategy, and this was supported by China (civil aviation was added in 2010). Subsequent meetings reviewed the work programs of each of the sector groups, refined or augmented their focus, and confirmed project areas for calls for proposals. Working groups are now in place for each of the sector areas of priority focus for both governments: **clean tech, agriculture, life sciences**, and **advanced manufacturing**. Each is co-chaired by senior officials with sector roles and responsibilities in each country – variously in government or research agencies. On occasion the Committee has been briefed on specific issues or opportunities in S&T collaboration, such as the briefings at its 2013 meeting on Mechanisms for Education and Research Institutions as well as a China/Canada Young Scientists Exchange initiative.

c) Projects

During the first five years, seventeen projects were selected across all the key sectors: $4.9 million for Canadian companies and university researchers, matched on China's side for their companies and university researchers. Projects included:

1. RoboNurse was designed to reduce back injuries of nurses by lifting, repositioning and transferring patients – this project involved the Toronto Rehabilitation Institute and two Canadian firms as well as Shanghai Jiaotong University and two Chinese companies.[95]

RoboNurse.
Credit: ISTP Canada.

2. A more environmentally sound pulp was developed, reducing the cost of making high quality pulp by 90 percent – this project involved the Universities of Toronto and New Brunswick with FPInnovations, a Canadian research institute as well as two Canadian

companies, with Tianjan University of Science and Technology and two Chinese companies.

3. Monitoring Systems for Nuclear Power Plants were developed, identifying a cost-effective wireless communications system to monitor the health and performance of equipment in nuclear plants – the project included Western University, Atomic Energy of Canada Ltd as well as the University of Electronic Science and Technology of China and Chongqing Sichuan Instrument Complex Co. Ltd.

4. A novel urinary diagnostic kit for acute kidney injury was developed – the project included the University of Alberta, ATGCell Inc., as well as Shanghai ChangZheng Hospital.

These are just a few representative examples of the partnerships created. Projects typically proceeded well, and deepened Canada and China's R&D relations, particularly in industry and academia.[96] One additional dimension facilitated by ISTPCanada was the three-way partnership with Israel in agricultural technologies; the collaboration led to the creation of a trilateral commission with leadership from Canada that brings together officials from the three countries to help cultivate opportunities for mutually beneficial R&D cooperation.[97] Furthermore, ISTPCanada was contracted to manage a similar peer review process for projects under the $6 million Alberta Global Technology Fund.[98]

In addition to the selection of the projects themselves, ISTPCanada conducted 27 partnership activities, such as networking workshops, conferences and symposia for researchers. Sometimes these partnerships led to the creation of teams which were ultimately successful in the ISTPP project approvals. A case in point is Professor Ben Tsang, at the University of Ottawa. His first Sino-Canada workshop resulted in 40 potential projects in women's reproductive health being identified. In a subsequent request for proposals from a joint CIHR and NSFC program, over four years, the University of Ottawa was successful in 6 of the 12 projects funded (in a success rate of 15%), and the participants of 11 of the 12 had attended that first Sino-Canada workshop. This is evidence that a small amount of funding can bring people together with substantive research following.

The ISTP Program was progressing well. An early formative program evaluation in 2008 found that it was meeting its objectives, and that ISTPCanada was a cost-effective organisation, despite the relatively small size of its budget; it was successful in levering resources from other agencies to supplement its administrative capacity. A summative evaluation in 2010 found that the amount of the financial support was not sufficiently robust to meet the program objectives, and the commercial success was less than expected by the Canadian recipients. Program delays deferred funding disbursements, but despite this, the arms-length agency was able to achieve leverage of non-federal funds of 3 to 1. The evaluation recommended that the department seek a significant increase in the level of funding for the program, and that increased flexibility be sought in the terms and conditions so that the coordinators of the sector teams would be able to direct programming to specific priority areas, and that the department undertake an assessment of the risks associated with an arms-length agency delivering on partnership relations with other countries.[99]

In November 2011, Prime Minister Harper had a bilateral meeting with President Hu Jintao during the APEC Summit in Honolulu. The same day he announced renewed support for the ISTP Program that would be used to implement additional projects under the Framework Agreement. In his statement, the Prime Minister said "Canada and China have much to share with one another in the area of science and technology. This support will enable our scientists to work together on innovative new ideas that can be brought to the marketplace to help generate jobs and economic growth".[100]

At the same time, would a number of fairly small projects such as those funded by Canada in the first five years of the program give each country the impact it was looking for? On February 8, 2012, when Prime Minister Harper and Premier Wen Jiabao met in Beijing they announced a decision of the Joint Committee to have a bigger impact by focussing the next competition on more financing in just two areas: energy efficient vehicles (or "clean cars") and human vaccine research at $4.5M for Canadian participants in each of these two areas of research, plus the Chinese contribution for their participants. In addition to base funding on the Canadian side, supplementary funding came from within the budgets of the Natural Sciences and Engineering Research Council (NSERC) and the Canadian Institutes for Health Research (CIHR) respectively. This is a model that could be extended in future. In this case, there was a requirement for at least one university and one company from each country. Projects included:

1. Condition monitoring of powertrain components in electrified vehicles, with McMaster University and D&V Electronics as well as Beijing Institute of Technology, Shanghai Edrive Co. and Eontronix Co.

2. Ultra high strength A1 and Mg alloys, hard coatings and their application in engine components, with University of Windsor and Ford Canada as well as CAS Institute of Mechanics and Great Wall Motor Co.

3. Bio-alcohol diesel combustion control for high efficiency and low emission diesel engines with University of Windsor and Ford Canada as well as Shanghai Jiao Tong University and Chang'An Motor Co. and Harbin Dong An Automotive Engine Manufacturing Ltd.

4. Novel Vaccines for respiratory syncytial virus and parainfluencza virus type 3 with VIDO-InterVac and Dalton Pharma Services Inc as well as Guangzhou Institute of Respiratory Disease and South China United Vaccine Institute Ltd.

5. "Nano-on–micro" delivery system for a vaccine/adjuvant against Helicobacter pylori with University of Western Ontario and PnuVax Inc and Axcelon Biopolymers Inc as well as Chongqing University and Chongqing Jinshan Science and Technology Group Co.[101]

These projects represent excellent research, and it is expected that the partnerships will result in further collaborations in years to come. In the grander scheme of things, however, these joint projects are small compared to the significant opportunity in China and the pace of developments there. They were designed to start up joint research in areas of emerging importance, which they have certainly accomplished, but Canada felt there was more that could be done. In an effort to broaden the discussion, at the fifth meeting of the Joint Committee, a draft Joint Action Plan was discussed, and it has now been agreed to and signed by both sides. The Action Plan includes concrete actions in each of the Joint Committee's priority sectors. It includes initiatives such as ISO standard development in environmental technology, industrial projects in aerospace, international consortia on genomics, roundtables for biomass and bioenergy transformation, joint research on agri-food production, commercialisation of agriculture technology, and workshops on biofuel transformation and quantum computing. There is a good representation of partners in government, academia and industry from both countries.

d) Challenges

The Government of Canada recognizes the challenge of engaging China as it accelerates its technology development, and Canada is expected to continue to give priority to partnering effectively with China to the benefit of Canadian companies and researchers. At the same time, there has been recognition that the ISTP Program and the Agreement itself had encountered a few challenges along the way. For example:

~ For Canada, the S&T Agreement is a treaty and binds departments and agencies. For MOST, it is more akin to an MOU such as it has with many countries, as it cannot bind other departments. But MOST has been effective in connecting with other agencies where partnerships hold benefits, as can be seen in the various initiatives laid out in the recent Action Plan;

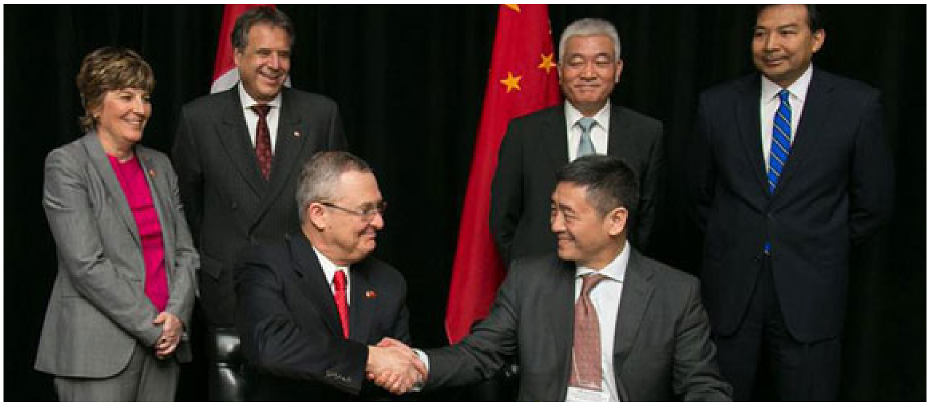
~ MOST has agreements directly with provincial governments, notably Alberta, British Columbia, Ontario and Quebec, thereby increasing the number of partnerships in which it can engage. Canada also has projects and exchanges in China's provinces and at even lower levels of jurisdiction such as municipal S&T commissions. In order to increase coordination, the Joint Committee has invited provincial representatives to attend as observers at recent meetings, and this will open up that window a little wider;

~ Canadian university and industry representatives were members of the Joint Committee at the beginning, and the membership on China's side was predominantly from MOST; there has been flexibility shown on the Canadian side to accept the membership that China believes will best support its participation, while China came to accept active members of the Committee from the university and private sectors and at a recent meeting had representation from a university and a company. Now membership is being reviewed again to better align it as a working committee since more continuity would be beneficial from one meeting to the next. Patience and flexibility on both sides have been needed, and is in the best spirit of international partnership;

~ The contribution agreement process, which requires funds to be spent in the year they are booked in the fiscal framework, is a practical constraint on the flexibility that one often needs in complex international projects. This became a mounting problem of program administration, and after detailed review it was decided to bring the program inside the government, passing responsibility to GAC working with NRC's commended Industrial Research Assistance Program, the highly commended program for helping SMEs with R&D funding and related advice.

~ During this period, China too had faced a potential challenge in its own operation of the collaboration. During the past three years, massive changes in China's science and technology programs and governance, whereby competed programs providing R&D funding that had previously been managed within the black box of each Ministry are now to be managed by "arms-length professional executive agencies" with peer review. These changes are described elsewhere in the literature[102] but it is worth noting that, after months of discussion, MOST was successful in persuading the Ministry of Finance that the International Program, with which it partners with Canada and other countries, will be retained within MOST so it can be managed closely as the bilateral conditions with each country require, rather than trying to fit it into one of the five new program areas identified by China's national government.

The Canadian program now called the **Canadian International Innovation Program** (CIIP) is funding joint collaboration with a number of countries including China.[103] So far, three projects in Guangdong Province are funded, and a broader call for proposals for projects across China is expected soon. In addition, three missions were organized on



Bogdan Ciobanu, VP, IRAP and Jin Xiaming, Director General, MOST shaking hands, with Alain Beaudet and Wang Zhigang standing centre behind them and Deputy Minister Christine Hogan and Chinese Ambassador Luo Zhaohui on either side. Credit: National Research Council.

clean tech to Hong Kong and Shenzhen, medical devices and health care to Beijing and Tianjin, and financial technologies to Hong Kong. One important factor as to the impact that the CIIP will have is the amount of funding devoted to it. The entire program funding of $5M per year is assigned to competitions for projects in all five countries: China, India, Brazil, South Korea, and Israel. Funding is allocated based on the best projects put forward from whichever countries have the best proposals. Project size is up to $2.4M, with the Canadian government contribution up to $600K, the Chinese government contribution the same, plus industry matching contributions from both countries. That clearly does not allow for many China projects to be funded at any one time.

While MOST is pleased to partner with the CIIP on delivering the program, it is fair to say that it pales in comparison with the targeted funding in other western countries that partner actively with China on STI. Australia has a much more extensive collaboration through a dozen virtual research networks, more than 100 joint research projects, and ten science symposia, along with R&D missions and researcher exchanges. Their efforts ramped up with their ChAFTA and are continuing to increase. The U.S. has many levels of engagement including an energy R&D centre, and the U.K. and Germany have both put a major focus on collaboration with China.

The experience of the CCJC to date with collaborative projects, combined with the Action Plan going forward, puts Canada and China's government-to-government S&T relations on a very positive trajectory. In addition, it was decided at the February 2016 meeting of the CCJC that Canada and China would launch an Innovation Dialogue. This will add a policy dimension to the programmatic focus of the Canada/China S&T relationship to date. China and the U.S. have had an **Innovation Dialogue** for many years, stemming initially from issues that the two countries were finding in trade in technology products. It was led in past on the U.S. side by the White House. Canada's Dialogue is likely to be different --- on the Canadian side it is led by officials of ISED and on China's by MOST. This will provide a forum to engage in broad S&T policy discussions.

7. POTENTIAL FOR FUTURE COLLABORATION IN 2018 AND BEYOND

The Liberal Government of **Prime Minister Justin Trudeau** is currently in the midst of resetting Canada's relationship with China. The Government launched exploratory discussions for a potential negotiation of a Free Trade Agreement, and the Prime Minister led an important mission to China in August and September of 2016 that established a strong relationship with **President Xi Jinping**, announcing 56 new commercial agreements worth $1.2B – many involving Canadian technology companies. That visit was returned a few weeks later when **Premier Li Keqiang** visited Ottawa and Montreal – and four more commercial agreements were announced. This has raised the bar on the potential for Canada's future relationship with China. Since these visits, there have been many meetings of officials hoping to further advance the Canada-China relationship on all fronts, including science and technology.

Prime Minister Justin Trudeau and President Xi Jinping.
Credit: Reuters/Damir Sagoli.

It is imperative that Canadian officials, business leaders, and researchers be aware that the new China, under President Xi Jinping, has spent the past four years completely changing the country's S&T governance and programs to bring them up to western standards of arms-length decision-making and peer review.[104] Very often it will be these new programs that will be funding the Chinese side of a joint partnership with Canadian companies and researchers. A series of detailed STI strategies with explicit instructions for implementation has been provided as top-down direction for SOEs, other companies, and university researchers – all designed to bring China up to and then move past other countries' competitive technology positions.[105] Its Indigenous Innovation Policy has set targets for enhancing China's own original technology development, absorbing technology from foreign companies via mergers and acquisitions and joint ventures, and increasing "re-innovation" by modifying foreign technology thereby making it Chinese.[106] Many billions of dollars are being devoted to:

- developing China's own scientists and engineers, and attracting talent from western countries, for China's research efforts;

- building world-class science facilities with top-of-the-line research equipment;

- mergers and acquisitions to buy all or majority control of technology companies all over the world;

- joint ventures to bring western technology into the Chinese market under a Chinese corporate entity; and

- lead and influence international technology standards in a wide range of sectors.

China has set aggressive targets for international leadership in science and technology, and is expected to meet those targets.[107]

Canada has much it can gain from becoming aware of these trends and taking advantage of them wherever possible. For example, China now has world-class Big Science projects, such as the massive Shanghai Synchrotron and the newly built Jinping Neutrino Observatory. Canadian researchers should be seeking to spend time in those facilities to advance their own research projects. Where they have already developed strong research relationships with Chinese researchers over years, this will be much easier to accomplish. And this also applies to researchers in many science disciplines where China is currently investing in world-class equipment.

The same principle applies to Canada's technology companies – there are sectors and technologies where China has research and ambitions to lead the world, particularly in advanced technologies, such as genomics, artificial intelligence and the Internet of Things. China is currently making huge investments in these, and other, research disciplines. Their plans are described clearly in magnificent detail in policy documents such as the Five Year Plan for STI, the Strategy for Innovation-Driven Development, China Manufacturing 2025, the Artificial Intelligence Strategy, and numerous State Council "Opinions" directives (which are like Canadian Cabinet Decisions).[108] Canadian researchers and companies must familiarize themselves with these strategies to identify where they can best benefit from China's plans and strategies – and then develop a strategy for how best to take advantage of these initiatives. Certainly other countries' governments, companies, and researchers are already doing these assessments. Canada will need to "get with the program" and see where its own technology needs can be advanced in future by partnering with China.

We are no longer in the 1950s, 60s, 70s, and 80s when China wanted to learn from Western countries and was absorbing any wisdom they could get from Canadian researchers, government officials, and companies. China is now leading the development of advanced research and new technologies. Canada needs to get out of the mode of identifying what China needs and offering it to them. We did that for many years and it helped China tremendously. The dynamic has changed. We now need to identify the sectors and technologies on which we can benefit from partnership with China, and where they are undertaking the most advanced research in the world. But to buy a seat at that table, our researchers and companies need to be reinforced with funding and resources to bring to the table. If Canada plans to negotiate an FTA, we need to go in fully informed with not just sector trade strategies but with technology strategies and the resources to back those up.

This takes us back to *xìn* or trust that was discussed at the outset of this paper. In the past few years, particularly due to the huge resources of SOEs, Chinese technology companies, and well-funded researchers, there has been a growing concern about how intellectual property and company collaborations are managed. While the Chinese government has made significant efforts to clean up the problems and address these concerns, Canadian companies need to be assured that their dealings with Chinese partners will be protected and dealt with in the same way as our companies' IP and commercial enterprises are protected through the judicial systems in other countries. This is not a revolutionary concept. Companies need to be sure that when they go into commercial ventures, the game-plan will not be changed on them. With the Indigenous Innovation Policy, it is clear to Canadians that China is looking out for China, and wants to partner where it will benefit their country. That, combined with the thickening of the China's Firewall, suggests that China is becoming more inward focussed, while wanting the advantages of Western technology. This is a real challenge for Canada moving forward. Is *xìn* really the ruling principle now – working with partners to advance mutual benefits, or is it Chinese companies out to gain advantage wherever they can on behalf of their nation? The Indigenous Innovation Policy is China-centric. Canada has to navigate a new path to partner for its own benefit.

As this paper demonstrates, there has already been a high level of collaboration between Canada and China in industry sectors, government to government, and through joint research initiatives and academic exchanges. All of these are expected to continue and to accelerate. Increased Canadian resources for targeted collaborations would reap great benefits for both countries, as China already has resources to bring to the table to match whatever its bilateral partners provide. The question is with which of many countries will it partner? Given the importance of China as an economic powerhouse and an emerging innovation leader, Canadian companies and researchers want to be well positioned to be those partners. The Government of Canada has made a start with the CIIP for funding targeted technologies. A significant ramp up of the program, in the context of an anticipated Canada-China FTA, could position Canada to engage with China more proactively and at a higher level of collaboration. This would clearly benefit Canadian companies as well as researchers in both universities and colleges.

And there remains still more potential in the area of governance, sharing ideas and best practices in science and technology policies and mechanisms. One area in particular in which there is much that China can learn from Canada is in our highly successful mechanisms for technology development and commercialisation such as our Networks of Centres of Excellence (NCE).[109] Like China, Canada is large geographically and has excellent researchers in each discipline distributed in centres across the country; this can duplicate research, waste resources, and lose economies of scale. Networks address these challenges, not by bringing researchers together physically, (though this can be facilitated annually in a conference) but by networking them around a common research agenda and projects. Where these mechanisms have been used, they have been critical to linking centres of excellence of academics and industry, particularly in emerging sectors such as wind energy and electric vehicles. And there are now Networks for Commercialisation and Business-Led Networks, both of which have proven highly successful in linking the best and the brightest in Canada around a common research plan and priorities. The geographic and commercialisation challenges experienced by Canada are similar in many ways to the challenges faced by China, and China may want to adopt Canada's best practices in this area. Canada's implementation of dozens of Networks of Centres of Excellence across research disciplines and industrial sectors could suggest practical models for addressing those challenges.

Furthermore, the model of a Network of Centres of Excellence has been further extended to Canada's important bilateral relationship with India. The India-Canada Centre for Innovative Multidisciplinary Partnerships to Accelerate Community Transformation and Sustainability (IC-IMPACTS) was selected through the NCE program for the development of research collaborations among researchers, industry innovators, community organisations, and government agencies in both countries. The Network has been tremendously successful in just a few years, with 38 projects funded, 630 people trained, 166 partners, and 191 researchers to date.[110] Extending this model to a new Canada-China network would allow both countries to reach a new level of collaboration, and exchange to advance technology development on both sides, and the engagement of government agencies would go a long way to obviate any IP or regulatory issues normally faced by firms and researchers operating in another country. Furthermore, it would be a significant initiative that could advance the principles and actions identified in the G20 Innovation Action Plan agreed to in 2016, including increasing collaboration and the mobility of highly qualified people.[111]

China's STI game plan for the coming years is laid out clearly in its *Strategy for Innovation-driven Development* and its *STI Five Year Plan*, as well as in the *State Council Opinions on the Innovation System*. These documents are very detailed and Canadian researchers in industry, government and academia should review them carefully to identify not just where Canada has strengths that can help Chinese partners and access its markets --- but where China itself has strengths that Canada can benefit from by partnering with China. With the rise of China's economy, and its STI expenditures and performance, it is now on par with and even excelling above countries in the West in some technology sectors. The historical one-way street of transfer of knowledge and technology from Canada to China has now become a two-way street, and both countries can benefit from mutual collaboration going forward.

ENDNOTES

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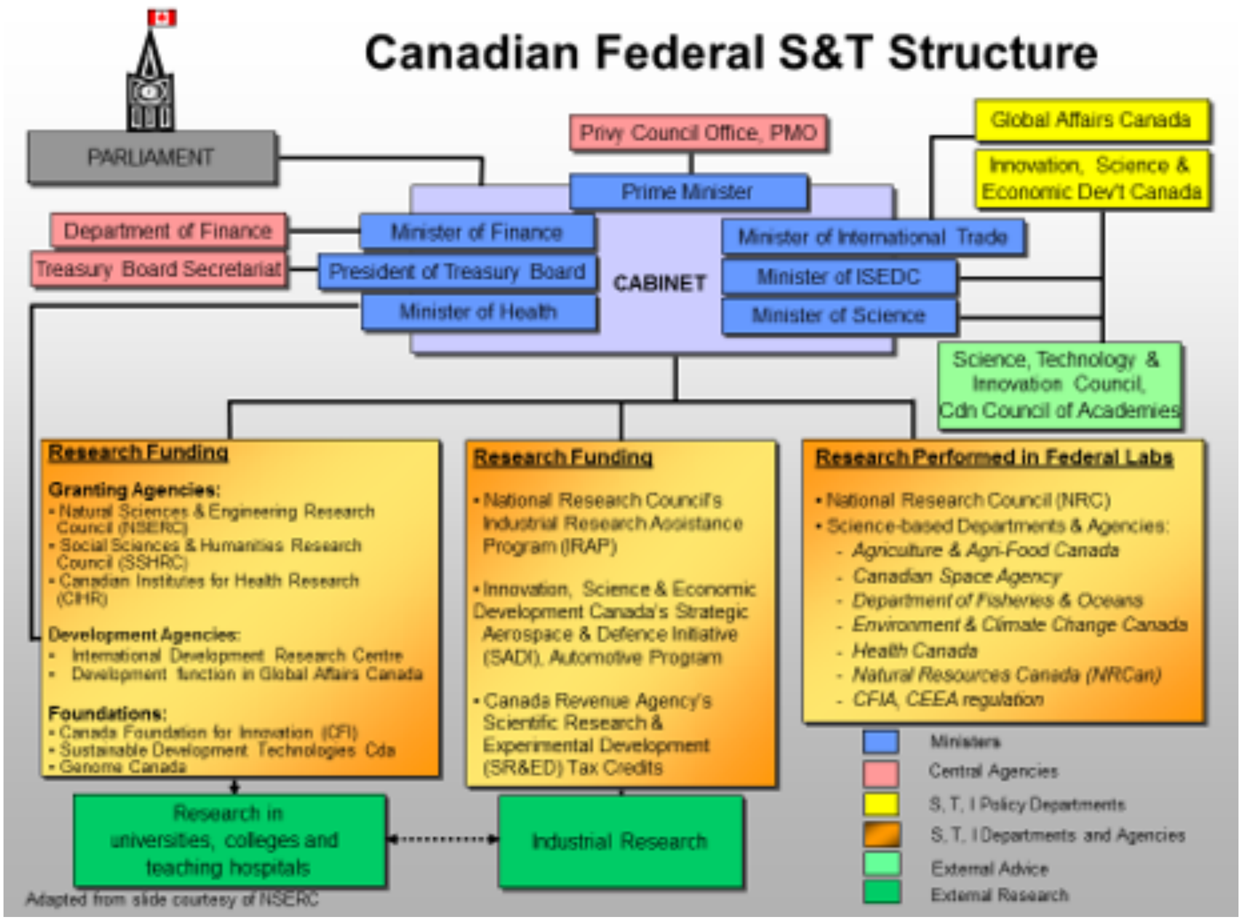
ANNEX A

List of Acronyms

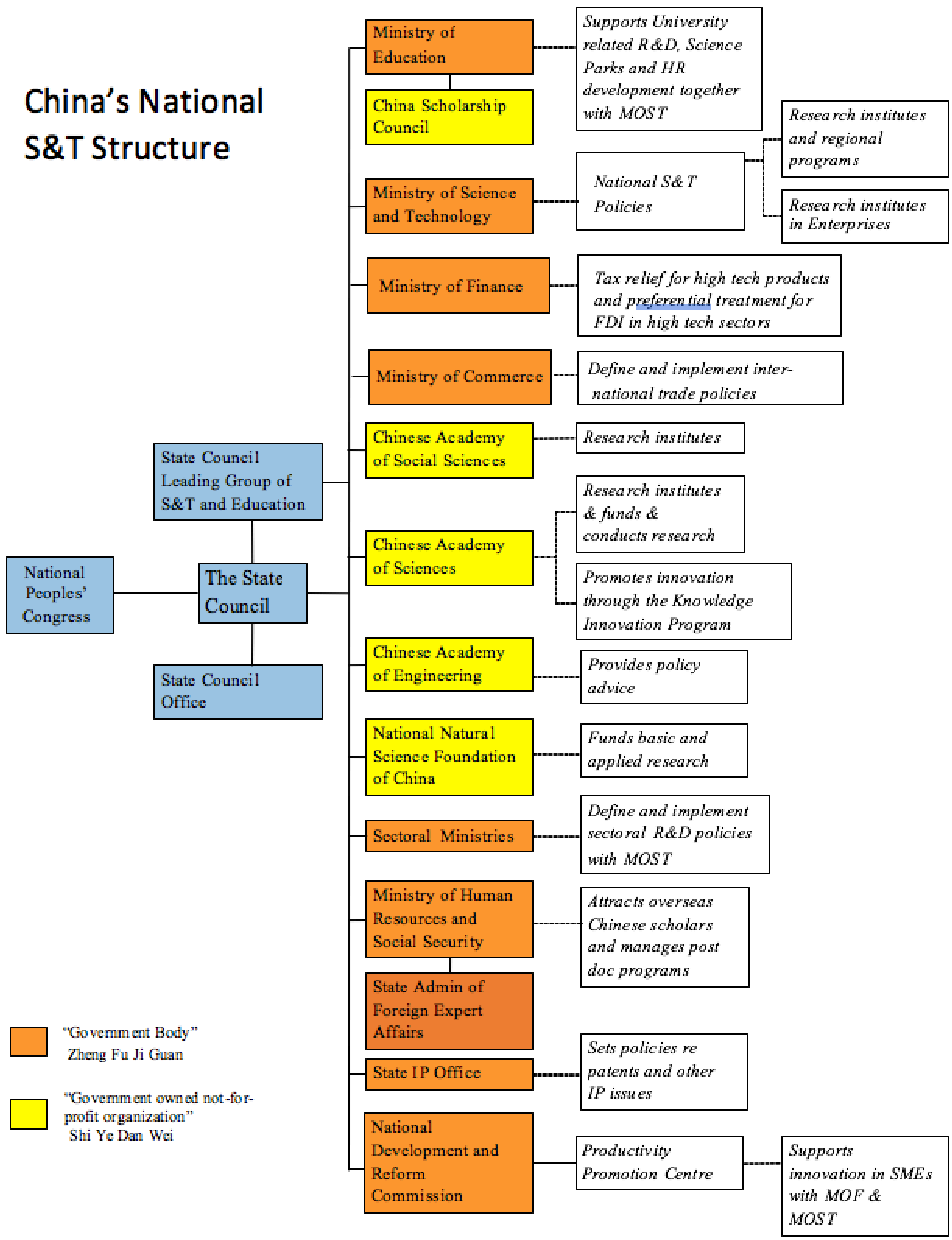
APEC	Asia-Pacific Economic Cooperation
AVIC	Commercial Aircraft Engine Company
BRICS	Brazil, Russia, India, China and South Africa
CAS	Chinese Academy of Sciences
CASC	Aerospace S&T Corporation of China
CASTED	Chinese Academy of Science and Technology for Development
CCICED	China Council for International Cooperation
CIDA	Canadian International Development Agency
CIHR	Canadian Institutes for Health Research
CIIRDF	Canada-Israel Industrial Research and Development Foundation
CNOOC	China National Offshore Oil Corporation
COMAC	Commercial Aircraft Corp of China
DFAIT	Department of Foreign Affairs and International Trade
FTA	Free Trade Agreement
GAC	Global Affairs Canada
GERD	Gross Domestic Expenditure on Research and Development
GFRC	Global Forum of Research Councils
GM	General Motors
GSC	Geological Survey of Canada
IC-IMPACTS	India-Canada Centre for Innovative Multidisciplinary Partnerships to Accelerate Community Transformation and Sustainability
ICT	Information and Communications Technology
IDRC	International Development Research Centre
ISTP	International Science and Technology Partnerships Canada
ISTPP	International Science and Technology Partnerships Program
ITARs	U.S. International Traffic in Arms Regulations
MLP	2006-2020 Medium to Long-term Plan for Science and Technology
MOST	Ministry of Science and Technology
MOSST	Ministry of State for Science and Technology
MOU	Memorandum of understanding
NRC	National Research Council
NRCan	Natural Resources Canada
NSE	Natural Sciences and Engineering
NSERC	Natural Sciences and Engineering Research Council
S&T	Science and Technology
SIMM	Shanghai Institute of Materia Medica
SMEs	Small and medium enterprises
SOE	State Owned Enterprise
STI	Science, Technology and Innovation
SSHRC	Social Sciences and Humanities Research Council
UNESCO	United Nations Educational, Scientific and Cultural Organization
WED	Western Economic Diversification Canada

ANNEX B

The structure of the Canadian federal science and technology decision-making system is set out below in this organigram:



The structure of the Canadian federal science and technology decision-making system is set out below in this organigram:



ANNEX C

Agreement for Scientific and Technological Cooperation between the Government of Canada and the Government of the People's Republic of China

E105085

THE GOVERNMENT OF CANADA and THE GOVERNMENT OF THE PEOPLE'S REPUBLIC OF CHINA, hereinafter together referred to as the "Parties";

ACTING in the spirit of the Joint Communiqué on the Establishment of Diplomatic Relations between the People's Republic of China and Canada, signed on Oct. 13, 1970;

CONSIDERING the importance of science and technology for their economic and social development;

CONSIDERING the ongoing scientific and technological cooperation between China and Canada;

RECALLING the Parties' rights and obligations pursuant to the Berne Convention for the Protection of Literary and Artistic Works (Paris Act, 1971), the Paris Convention for the Protection of Industrial Property (Stockholm Act, 1967) and the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS);

CONSIDERING that China and Canada are currently pursuing research and technological activities, in a number of areas of common interest and that participation in research and development activities on the basis of reciprocity will provide mutual benefits;

DESIRING to establish a framework for cooperation in scientific and technological research, which will extend and strengthen the conduct of cooperative activities in areas of common interest and encourage the application of the results of such cooperation to their economic and social benefit;

HAVE agreed as follows:

Article 1 - Purpose

The Parties shall encourage, develop and facilitate Cooperative Activities in science and technology for peaceful purposes, in fields of common interest and on the basis of equality and mutual benefit.

Article 2 - Definitions

For the purpose of this Agreement:

"Cooperative Activity" means any activity carried out pursuant to this Agreement;

"Implementing Arrangement" means an arrangement in written form between the Parties or between two or more Participants, for the conduct of a Cooperative Activity, but excluding an arrangement between two Participants from the same Party;

"Information" means scientific or technical data, including design procedures and techniques, product formulas, manufacturing methods, processes and treatments, the chemical composition of materials, computer programs, data compilations and employee know-how such as specialized skills and experience; business information, including strategic and marketing plans, financial information and credit or pricing policies; client-related information, including customer lists, customer preferences and contracts; and any other data as may be jointly decided in writing by the Parties;

"Intellectual Property" shall have the meaning set out in Article 2 of the Convention establishing the World Intellectual Property Organization, done at Stockholm on 14 July 1967;

"Joint Research Activity" means a Cooperative Activity in research, technological development or demonstration that involves collaboration by Participants from both Parties and is designated as a Joint Research Activity in writing by the Participants;

"Participant" means any individual or legal entity established pursuant to the legislation of either Party and includes, but is not limited to, academies of science, governmental and non-governmental organizations, universities and colleges, institutes of technology, science and research centres and institutes, private sector enterprises and firms.

"Technology Management Plan" means a contract in written form between two or more Participants concerning the ownership and use of Intellectual Property rights that may be developed or created in the course of a specific Joint Research Activity, but excluding a contract between two Participants from the same Party.

Article 3 - Principles

Cooperative Activities shall be conducted on the basis of the following principles:

a. mutual benefit based on an overall balance of advantages;
b. reciprocal access to the activities of research and technological development undertaken by each Party or its Participants, where practicable;
c. timely exchange of Information, which may affect Cooperative Activities;
d. effective protection of Intellectual Property rights;
e. peaceful, non-military uses; and
f. respect for the applicable legislation of the Parties.

Article 4 - Areas of Cooperative Activities

Areas of Cooperative Activities shall be jointly decided in writing from time to time by the Parties.

Article 5 - Forms of Cooperative Activities

1. Subject to their applicable legislation, the Parties shall foster, to the fullest extent practicable, Cooperative Activities under this Agreement. The Parties and their Participants shall conduct such Cooperative Activities through the conclusion of specific Implementing Arrangements or contracts.
2. Cooperative Activities may take the following forms:

a. joint research and development activities;
b. pooling of research and development projects, already underday in each Party, into Joint Research Activities;
c. facilitation of commercially viable research and development;
d. organization of scientific seminars, conferences, symposia and workshops, as well as participation of experts in those activities;
e. exchanges and loans of equipment and materials;
f. exchanges of information on practices, laws, regulations and programs relevant to the Cooperative Activities undertaken pursuant to this Agreement;
g. funding of Cooperative Activities on the basis of equal contributions from each Party;
h. demonstrations of technologies and applications development;
i. visits and exchanges of scientists, technical experts and academics; and
j. any other mode of cooperation jointly decided in writing by the Parties.

3. Joint Research Activities shall be implemented when the Participants concerned have developed a Technology Management Plan pursuant to the Annex to this Agreement.
4. In case of any inconsistency between this Agreement and an Implementing Arrangement or contract entered into pursuant to this Article, the Agreement shall prevail.

Article 6 - Coordination and Facilitation of Cooperative Activities

1. The coordination and facilitation of Cooperative Activities under this Agreement shall be effected on behalf of China, by the Ministry of Science and Technology and, on behalf of Canada, by the Department of Foreign Affairs and International Trade, acting as Executive Agents. Each Party may designate another Executive Agent should its Executive Agent identified in this paragraph cease to be responsible for the subject-matter of this Agreement. The Party designating another Executive Agent shall notify the other Party in writing of the name of its new Executive Agent.
2. The Executive Agents shall establish a Joint Committee on Science and Technology Cooperation, hereinafter referred to as the "Joint Committee". The Parties shall each designate a co-chairperson and an equal number of representatives to sit on the Joint Committee. The Joint Committee shall operate on the basis of consensus. It shall establish its own rules of procedure.
3. The functions of the Joint Committee shall be to:
   a. promote and oversee the different area of Cooperative Activities as decided by the Parties pursuant to Article 4 of this Agreement;
   b. identify among the forms of Cooperative Activities, listed in Article 5 of the Agreement, priority forms of Cooperative Activities for each calendar year;
   c. propose, pursuant to Article 5 of this Agreement, the pooling of certain research and development projects which would be of mutual benefit and complementary;
   d. advise the Parties on ways to enhance and improve cooperation consistent with the principles set out in this Agreement;
   e. review the functioning and implementation of this Agreement;
4. The Joint Committee shall meet every two years according to a jointly determined schedule. The meetings should be held alternately in China and in Canada. Extraordinary meetings may be organized at the request of either Party.
5. The costs incurred by members of the Joint Committee in the exercise of their functions shall be borne by the Party who has designated them. The costs, other than those for travel and accommodation, which are directly associated with meetings of the Joint Committee shall be borne by the host Party.
6. To carry out its functions, the Executive Agent of each Party shall designate an Executive Secretary. The Executive Secretaries shall act as points of contact for communications between the Parties relating to matters covered by this Agreement. The Executive Secretaries shall meet at least once a year. The Executive Secretaries shall provide to the Parties a joint annual summary report on the status, the level reached and the effectiveness of Cooperative Activities undertaken pursuant to this Agreement.

Article 7 - Availability of Resources

Cooperative Activities shall be subject to the availability of appropriated funds, personnel and other resources.

Article 8 - Persons, Material, Information and Equipment

Each Party, subject to its legislation, shall take all reasonable steps and use its best efforts, to facilitate entry to, sojourn and exit from its territory of persons, material, Information and equipment involved in or used in Cooperative Activities undertaken pursuant to this Agreement.
Article 9 - Peaceful Non-Military Uses
Each Party shall ensure that all funds, material, Information, equipment, services, technology and expertise provided to it or its Participants in connection with the implementation of this Agreement shall be used solely for peaceful, non-military purposes and in a manner consistent with this Agreement.

Article 10 - Use and Dissemination of Information

1. Each Party shall ensure that Information that is transmitted under this Agreement or created as a result of its implementation and that it considers to be confidential is clearly defined and

identified as such, through appropriate marking or otherwise.
2. Information covered by this Article shall be protected in accordance with the legislation applicable to the Party or Participant receiving the Information. Subject to the legislation applicable to the Party or Participant receiving the Information, such Information shall not be divulged or transmitted to a third party not directly involved in the implementation of this Agreement without the written permission of the Party or Participant that provided the Information.
3. Parties shall take all reasonable measures, in accordance with this Agreement, their respective legislation and international law, to protect Information covered by this Article against unauthorized use or disclosure.

Article 11 - Intellectual Property

1. Nothing in this Agreement shall be construed as granting to the other Party or its Participants any rights in Intellectual Property belonging to a Party or its Participants that came into existence prior to or outside the scope of this Agreement.
2. All rights in Intellectual Property developed exclusively by one Party or a Participant in the context of a Cooperative Activity undertaken pursuant to this Agreement shall vest in that Party or Participant.
3. Each Party shall ensure that any Intellectual Property it holds and that is necessary for the effective conduct of a Cooperative Activity by the other Party or its Participants, shall be made available to such Party or its Participants prior to the commencement of the Cooperative Activity. Each Party shall take reasonable measures to ensure that its Participants provide the Intellectual Property they hold, and that is necessary for the effective conduct of a Cooperative Activity, in the same manner. In any event, a Party or its Participants shall not be required to grant more than a licence to use such Intellectual Property for the conduct of the Cooperative Activity concerned. The Intellectual Property that is necessary for the conduct of a Cooperative Activity shall be specifically identified in the Implementing Arrangement or contract relating to such Cooperative Activity.
4. Intellectual property rights related to inventions, discoveries and other science and technology achievements jointly developed solely by the Parties within the context of Cooperative Activities shall be allocated to each Party in accordance with the proportions jointly decided by the Parties in writing.
5. Unless the Parties agree otherwise in writing in accordance with their domestic procedures, any Intellectual Property arising from the results of a Joint Research Activity shall be governed by the Annex on Intellectual Property Arising from the Results of Joint Research Activities, which forms an integral part of this Agreement.

Article 12 - Claims

1. For the purposes of this Article, the following terms shall be defined as follows:
 a. “Damage” includes personal injury, loss of life, direct, indirect and consequential damage to property, economic loss or infringement of rights;
 b. “Claim” includes demands, loss, costs, actions, suits or other proceedings of any kind;
 c. “Party” includes a Party and its officers, servants, employees or agents.
2. Each Party shall waive all Claims it may have against the other Party based on Damage arising out of the implementation of this Agreement, with the exception of the Claims related to the enforcement of the express provisions of a contract or Intellectual Property Claims governed by Article 14(2) of this Agreement.
3. Notwithstanding paragraph 2 of this Article, each Party shall indemnify and hold harmless the other Party from and against any Claim for Damages, to the extent that the Damage arises from omissions or acts of the former Party’s officers, servants, employees or agents, done with the intent to cause Damage or resulting from negligence, and carried out in the course of the implementation of this Agreement.

Article 13 - Existing Rights and Obligations

This Agreement shall not affect the rights and obligations of a Party resulting from other international agreements to which it is party.

Article 14 - Dispute Settlement

1. The Parties shall endeavour, in good faith, to resolve any dispute between them arising from the interpretation or implementation of this Agreement amicably, through consultations. Consultations shall take place as soon as reasonably practicable under the circumstances.
2. In particular, the Parties shall endeavour to resolve any dispute arising from the implementation of Article 11 or the Annex to this Agreement through consultations. Should such a dispute not be resolved within a reasonable time, the Parties may mutually decide to refer it to arbitration. Arbitration shall be subject to the Arbitration Rules of the United Nations Commission on Trade Law (UNCITRAL).

Article 15 - Entry into Force, Amendment and Termination

1. This Agreement shall enter into force on the date of the latter written notification that domestic procedures necessary for its entry into force have been completed by the Parties.
2. This Agreement shall remain in force for an initial period of five years. It shall automatically be renewed for subsequent periods of five years, unless either Party notifies the other Party in writing of its intention not to renew the Agreement, at least ninety days prior to its expiry date.
3. This Agreement may be amended by mutual written agreement of the Parties. An amendment shall enter into force on the date of the latter written notification that domestic procedures necessary for its entry into force have been completed by the Parties.
4. This Agreement may be terminated at any time by either Party upon six months' written notice to the other Party. Notwithstanding any termination of this Agreement, the obligations hereunder shall continue to apply to any Implementing Arrangement for its duration. Obligations under Articles 9 (Peaceful Uses), 10 (Use and Dissemination of Information), 11 (Intellectual Property) and 12 (Claims), as well as the Annex to this Agreement, shall remain in effect, regardless of the expiry or termination of this Agreement, unless otherwise agreed to in writing by the Parties in accordance with their domestic procedures.

IN WITNESS WHEREOF, the undersigned, being duly authorized thereto, have signed this Agreement.

DONE at Beijing on the 16th day of January 2007, in duplicate, in the English, French and Chinese languages, each version being equally authentic.

David Emerson
For the Government of Canada

Xu Guanhua
For the Government of the People's Republic of China

Annex on Intellectual Property Rights Arising from the Results of Joint Research Activities

Article 1 - Application

1. Each Party shall ensure that the other Party and its Participants are given the opportunity to obtain the rights to Intellectual Property allocated to them by or in accordance with this Annex.
2. This Annex does not alter or prejudice the allocation of Intellectual Property rights between a Party and its nationals or Participants, which shall be determined by the laws and practices of that Party.

Article 2 - Intellectual Property Rights Arising from Joint Research Activities

1. Terms used in this Annex shall have the same meaning as those defined in Article 2 of the Agreement.
2. The Parties shall:
    a. notify one another within a reasonable time of the creation of new Intellectual Property rights arising from a Joint Research Activity undertaken pursuant to this Agreement and shall, as appropriate, seek protection for such Intellectual Property rights, within their respective

jurisdictions and pursuant to their domestic legislation; and

b. ensure that the Participants from the other Party receive treatment no less favorable than that afforded under applicable international law in respect of Intellectual Property.

3. The Parties shall ensure that, for each Joint Research Activity, the Participants shall jointly develop a Technology Management Plan (hereinafter referred to as the "TMP") in respect of the ownership and use of Intellectual Property rights that may be developed or created in the course of the Joint Research Activity. The TMP shall be developed by the Participants taking into account the applicable legislation of the Parties, including legislation relating to the transfer or export of controlled Information, goods or services; the aims of the Joint Research Activity; and the relative financial or other contribution of each Party and its Participants.
4. With respect to Intellectual Property, the TMP shall address: ownership; protection; user rights and obligations for research and development; exploitation and dissemination, including arrangements for joint publication; the rights and obligations of visiting researchers (i.e., researchers not coming from either Party or one of its Participants), including the allocation to and acquisition by Participants of rights and obligations in respect of Intellectual Property generated by visiting researchers; and dispute settlement procedures, including arbitration where appropriate.
5. Intellectual Property rights generated by a Joint Research Activity, the allocation and acquisition of which has not been addressed in the TMP, shall be allocated, to the largest extent possible on the basis of the principles set out in the relevant TMP, as jointly decided in writing by the Participants.
6. Each Party shall take all reasonable measures to ensure that, in its territory, the other Party and its Participants shall be able to exercise the Intellectual Property rights allocated to them in accordance with this Annex and the Agreement.

Article 3 - Publication of Research Results of a Joint Research Activity

1. Without prejudice to Article 2 of this Annex, and unless otherwise agreed in the TMP concerned, publication of results of a Joint Research Activity shall be effected jointly by the Parties or Participants in a Joint Research Activity.
2. Subject to Paragraph 1 of this Article, the following procedures shall apply:
    a. The Parties shall take reasonable measures to encourage the publication of literary works of a scientific character arising from a Joint Research Activity undertaken pursuant to this Agreement; and
    b. The Parties shall ensure that all copies of a work that embodies the results of a Joint Research Activity, that is subject to copyright and that is distributed to the public, shall contain the names of the author(s) of the work unless an author explicitly declines to be named, as well as a clearly visible acknowledgement of the cooperative support of the Parties.

ANNEX D
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