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CHINA EMBARKS ON MAJOR CHANGES IN SCIENCE AND TECHNOLOGY

By Margaret McCuaig-Johnston & Moxi Zhang

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FOREWORD

The fluorescence of the Chinese economy is arguably the most significant economic development of the last 50 years. In terms of long-term impact on the global economy the rise of China could easily be said to be one of the most important events of the past century. Almost anything that relates to the China can be said to be complex, as befits a large and populous state. To understand how China has arisen, and to comprehend how this sustained growth was accomplished is a complex task, far beyond the purpose of this Occasional Paper.

However, one of the tools that facilitated the rapid development of China's economy was the systematic development of an ambitious national science and technology initiative. This paper, I believe, provides a comprehensive study of the PRC S&T policies, which have brought China for the first time into the ranks of the leading S&T powers.

The China Institute is proud to publish the work of Margaret McCuaig-Johnston and Moxi Zhang.

Beyond the acknowledgements listed in the text, I wish to thank CIUA member Kerry Sun for his editorial support, and Vivian Mak for her design and formatting contribution. As well, I wish to thank the reviewers of this paper, both academic and governmental, for their contributions.

Gordon Houlden

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TABLE OF CONTENTS

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EXECUTIVE SUMMARY

In the decades since the 1978 announcement by Deng Xiaoping of reform and opening, the Government of China has made significant and increasing investments in science and technology in order to drive economic development and growth. It has done this through a suite of programs that have been introduced consecutively over the years, but which have often suffered from a lack of coherence and coordination resulting in an inefficient allocation of resources and lost opportunities for world-class technology development. The consequences of this have included a delay in China's transitioning from industrial sectors assembling for export on the basis of others' technology to one that features homegrown value-added knowledge intensive products, services and brands marketable on a global scale. Furthermore, these inefficiencies and lost opportunities occur despite Five Year Plans that have identified government priorities, and even Medium- to Long-term Plans (MLP) of 15 years scope which have provided additional focus through both sectoral priorities and support of enabling technologies, most recently setting a 2.5% R&D intensity target for GERD as a percentage of GDP by 2020.

The financial investment has been massive for a developing economy, and we can see the results in the performance impacts which have pulled China out of underdeveloped status to a point where it is now positioning itself as an economic superpower with a stated objective of being a world S&T power by 2050. However, there are continuing problems with lack of coordination across the S&T programs, insufficient levels of excellence in what is funded, and concerns on the part of researchers with the lack of transparency in the selection processes in some programs. This paper identifies the major players in China's S&T policy and programs, and provides in one place the details of the most significant programs and how they work, as well as tracking the key performance variables for innovation in the economy.

On September 30, 2013, President Xi Jinping made clear that he intended to address the problems affecting China's national innovation system. In a major policy speech to the Political Bureau of the Central Committee of the CPC, he laid out his vision of science and technological innovation in support of social productivity and comprehensive national strength, and he identified the need to reform China's S&T system by removing institutional obstacles that stand in the way of innovation-driven development. He said that the government must improve incentive mechanisms and the policy environment, as well as the overall efficiency of the national innovation system. He then mandated a major mid-term review of the current MLP, including seeking focussed advice from international experts on China's S&T system, with the intention of addressing issues such as research integrity, intellectual property, indigenous technology, and problems in program delivery.

On March 3, 2014, the State Council issued detailed directives on improving and strengthening the management of scientific research programs and funds, and then on October 20, 2014 the Government announced a major shake-up of S&T governance and program structure. A "Ministerial Joint Meeting System" was put in place to manage the changes, chaired by the Minister of S&T and supported by the powerful NDRC and the Ministry of Finance. All S&T programs where projects are selected through a competitive process will be managed by third party institutes rather than by ministries such as MOST and MIIT where they are currently located, and there will be a focus on China's national strategic development projects. A comprehensive suite of programs is being created and current programs are already being assessed for necessary changes, with the dissolution, merger and creation of new programs under the new rubric all on the table. In the course of this process, S&T programs that are seen to have substantive or process problems will have those addressed. Improved transparency should be a major result of these changes, with programs relying more consistently on the peer review system that is common in Western jurisdictions, and there will be an increased emphasis on industry needs. The changes will see a loss of power and role for some organisations, with an increased role for others, and is consistent with the wider streamlining of government administration currently underway in China.

The nearly 100 programs affected are to be integrated into a unified platform, and on March 11, 2015, it was announced that 47 of these had already been integrated. In addition, there is much work to be done on the financial base budgets of these programs—the current annual funding at stake is $39.5B USD, a massive expenditure that is now at play with a relatively short timeframe to completion of three years. On March 5, 2015, Premier Li Keqiang released a report linking entrepreneurship and innovation as drivers of the economy, promising measures to protect intellectual property rights and to further open up industries to market competition, while providing financial incentives for researchers to increase innovation and develop inventions. Foreign technology experts will be incented to work in China through facilitated permanent residence status and perhaps even citizenship, and foreign research institutes will be encouraged to participate in national S&T projects.

In the same spirit, President Xi has signalled the intention to create in China new world-class think tanks. In some cases, these could be the policy think tanks that are currently housed within ministries and central agencies such as the Chinese Academy of Science and Technology for Development within MOST and the Development Research Centre within the State Council Office. Four categories of think tanks have been identified including military/political, social sciences, university-based, and private think tanks. It will be interesting to monitor the extent to which the Government of China really welcomes the kind of advice that truly independent world-class think tanks offer to Western governments. Perhaps it is telling that President Xi has indicated that some of these new organisations will be "think tanks with Chinese characteristics".

Given the increasing strengths of China's innovation systems and economy, this is a country with which Canadians should be ramping up its partnering. It will be important that our governments, businesses and research organisations understand the changes currently underway, as they will have a significant impact on their Chinese partners in how they work and the choices they make. Indeed, the changes could affect Canadians' own ability to work and research in the country, potentially for the better. This paper describes these changes as they are known to date. Furthermore, as China becomes a world leader in innovation, we should aim to collaborate with Chinese partners as easily as we do with American scientists and innovators, with a long term and robust commitment to the relationship.

INTRODUCTION

China's rise from rural communes to an emerging international force in science, technology and innovation (STI) is one key factor in its ability to become an economic superpower. Canada's unique STI strengths, particularly in aerospace, energy, biotechnology and agriculture technologies, are of interest to China, and STI is now very much a part of the trade and collaboration agendas of both countries. In order to understand China's current economic strength, it is important to understand the role that STI is playing in its development. The timing of this review is propitious, as on October 20, 2014 the President of China announced major changes to its STI governance and programs.

Focussing on three distinct phases of China's STI history, this paper will describe China's STI governance, plans and programs put in place over the years, review the impacts of these since the Reform and Opening begun in 1978, and discuss the recent governance and program changes made by President Xi Jinping. Through a Canadian lens, the paper will assess STI strengths as well as continuing barriers, and suggest considerations for Canadian governments (both federal and provincial) as well as Canadian businesses and researchers. This paper builds on the Canada chapter of an upcoming book on China's international S&T relations with other countries.[1] There is potential for follow-on analysis of the impacts of specific STI projects on the economy of China.

[1] Margaret McCuaig-Johnston wrote the Canada chapter for a book to be published in 2015 on China's international relations with ten other countries, entitled *China's Evolving International Science and Technology Relations*, edited by Dr. Denis Simon of Arizona State University.

BACKGROUND

Going back to the beginning of the People's Republic of China, Mao Zedong believed that China needed science and technology to become an international leader through his Superpower Program. He had started off well—exactly one month after the declaration of the PRC, on November 1, 1949, the Chinese Academy of Sciences was created. But later in the next decade, Mao's solution to bring his rurally-based country into the industrial age was to launch, in 1958, the horrific four year-long Great Leap Forward in which most food grown was diverted for the state. Ordinary Chinese were instructed to melt down their steel implements in "backyard furnaces" to create millions of tons of metals for the country—as a consequence, close to 36 million died and there was a consequent shortfall of births for a total population loss of 76 million, and China moved even further backward.[2] During this period, wheat shipped from Canada was one of the few forms of support the population had.

Then the Cultural Revolution intervened and for many years there was little connection with the West on science or technology, or even on trade. Canada's recognition of China's government in 1970, before most other Western countries, led to more contacts between the two countries as well as the admission of Chinese students to Canadian universities in 1972.

Yet, it was Deng Xiaoping's announcement of "Reform and Opening" in 1978 that started the more serious efforts of the Chinese government to learn from the West in key sectors. By then, there was much lost capacity that had to be restored so that China could begin to move forward again. According to Mao Zhongying, Science Counsellor at the Embassy of China in Ottawa and an S&T diplomat of many years' standing, China's development through science and technology can be seen in three phases: Reform and Opening, beginning in 1978; the initiation of the 15 year Medium- and Long-Term Plan (MLP), announced in 2006; and the new era of President Xi Jinping who, in 2013, launched a mid-term review of the MLP that led to the major governance and programmatic changes set in motion on October 20, 2014.[3]

[2] Yang Jisheng, *Tombstone: The Great Chinese Famine 1958-1962* New York: Farrar, Straus and Giroux, 2008 (2012 in translation) p.430.

[3] Interview with Mao Zhongying, Counsellor, Science and Technology, Embassy of the PRC in Canada, Ottawa, November 25, 2014.

I. REFORM AND OPENING: National Development through Science & Technology

With Reform and Opening, the Government of China hoped to use science and technology to serve national economic development goals. As described by Deng Xiaoping, "the new economic structure must be favourable to science and technology advancement, and the new R&D system should, in turn, be conducive to economic growth."[4] In 1982, Deng personally inscribed the name of the National Research Centre for Science and Technology Development (NRCSTD) in his own calligraphy – an indication of the importance that he assigned to S&T in the future of China, and a source of pride even today for officials who show the calligraphy to visitors to their boardroom.[5] Though the country was still recovering after the Cultural Revolution, enormous resources were devoted to build capacity in research and education. It is interesting to see how this technology-driven development evolved to build the economic powerhouse that China has become. Spending on R&D now surpasses that of all other countries except the US, and China now graduates by far the most scientists and engineers, generating higher numbers of patents and publications every year. These are very powerful inputs to an innovative society.

[4] Deng Xiaoping as quoted by Song Jian, "Science Reforms Vital", *Science*, August 9, 1985, p. 526.

[5] *CASTED: Chinese Academy of Science and Technology for Development*, an overview publication of the Ministry of Science and Technology, p 7. NRCSTD is the predecessor organisation of CASTED which was renamed in 2007; it is the S&T policy research and advisory branch of MOST.

1. S&T GOVERNANCE

The STI governance structure discussed below has been in place during most of this period of dramatic investment in research and development, along with the growth of China's private sector and the elevation of many of its universities and institutes of technology to world-class levels of excellence. The primary organizations with overarching responsibility for directing the STI system of China are the National People's Congress, the Political Consultative Conference, the State Council, and the State Council Leading Group of Science, Technology & Education (LGSTE)[6] , sometimes known as the State Science and Education Steering Group. While we will focus most of this paper on the national level of government, it is recognized that provincial and local governments are playing an increasingly important role in the funding of research and development and related S&T activities.

The Leading Group was created in 1983 and was chaired at that time by Premier Zhao Ziyang in order to provide "more political muscle" within the governmental framework.[7] It is similar in function to the Cabinet Committees familiar in Western governments but it meets less often—normally twice to four times a year to reach agreement on the country's most important decisions on S&T development. The Leading Group was given a prominent role in guiding national S&T policies and managing S&T strategic issues.[8] It is responsible for long-range S&T planning, the targeting of key S&T areas for national development, and cutting across vested interests in other S&T organisations to ensure that national development goals are met. In addition, it was to ensure that civilian and military S&T are well integrated.[9]

Leading Group members represent the agencies which play significant roles both in the development and implementation of S&T policies, including the Chairman of the National Development and Reform Commission (NDRC), the Minister of Education (MOE), the Minister of Science and Technology (MOST), Minister of Finance (MOF), Minister of Agriculture (MOA), the Dean of the Chinese Academy of Sciences (CAS), the Dean of Chinese Academy of Engineering (CAE), and the Director of National Natural Science Foundation of China (NSFC).[10] However, the Leading Group has not taken on a coordination role, nor is it staffed to; its secretariat within the State Council Office does not have sufficient manpower or the incentive to coordinate across all ministries and agencies.[11] And as we will see below, lack of coordination is one of the large gaps in China's S&T large and complex governance system.

[6] The chairman of the Leading Group is the Premier of the State Council, currently Premier Li Keqiang.

[7] Tony Saich, "Reform of China's Science and Technology Organizational System" in Denis Fred Simon and Merle Goldman editors, *Science and Technology in Post-Mao China*, Cambridge: Harvard University Press, 1989, p. 75.

[8] Swissnex, *A Quick Overview of the Science and Technology System in China*, 2009, p.2.

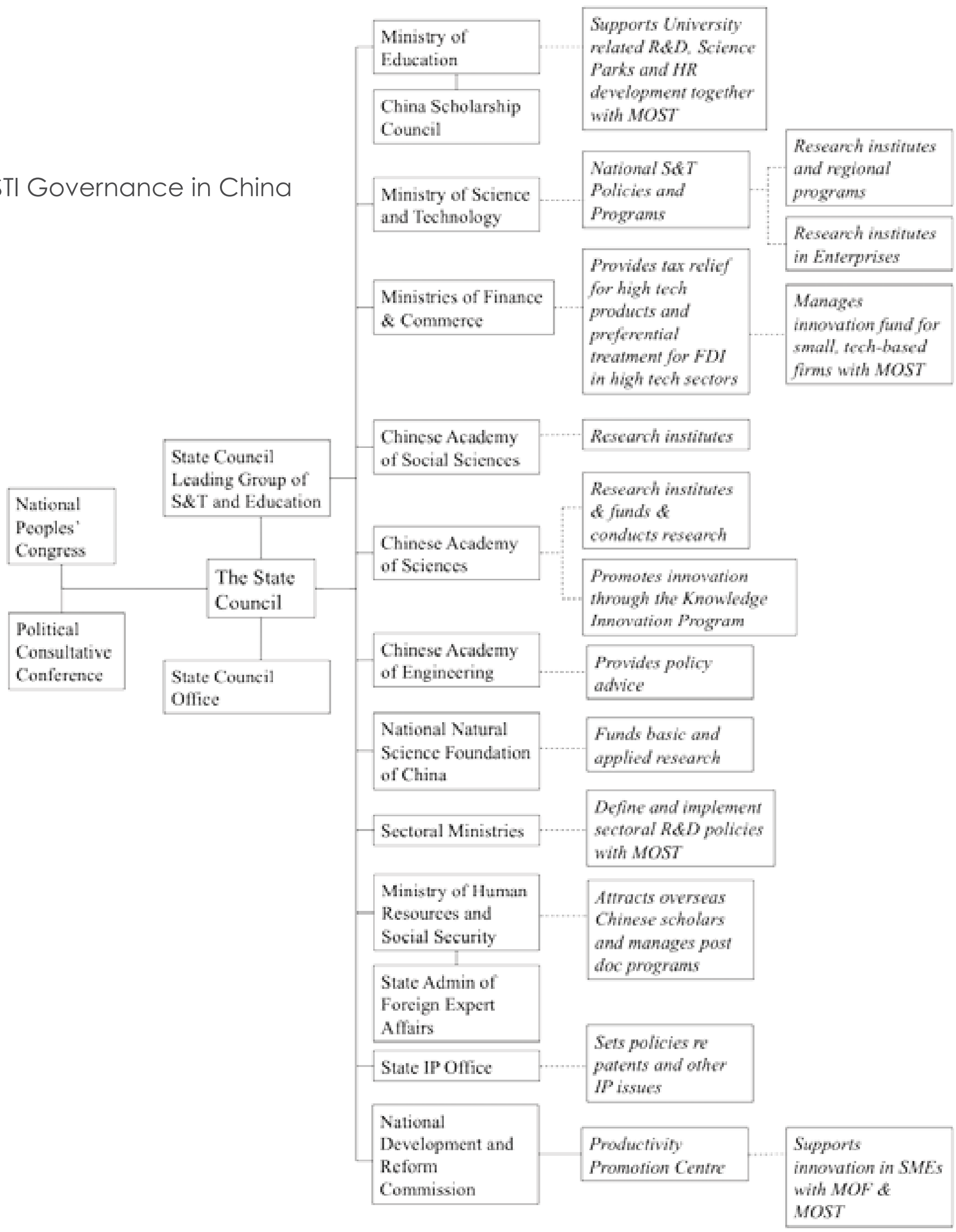
[9] Tony Saich, p.75.

[10] See: http://www.guancha.cn/Education/2013_08_31_169472.shtml

[11] Cong Cao, Ning Li, Xia Li, Li Liu, "Reforming China's S&T System", *Science*, Vol. 341 August 2, 2013.

Important roles in China's S&T governance have been taken by the ministries and agencies represented on the Leading Group, as well as by sectoral ministries such as the Ministry of Agriculture (MOA), the Ministry of Industry and Information Technology, the Ministry of Housing (MoH) and Urban-Rural Development, and the National Health and Family Planning Commission (NHFPC). The roles of the key ministries and agencies in Figure 1[12] are described in more detail at Appendix 1.

Figure 1:
Structure of STI Governance in China



S&T / R&D Budgets of Ministries and Agencies

For many years, the budgets of all Chinese ministries and agencies were kept internally and hidden to outside analysts and other governments. However, China has begun to recognize the importance of transparency and has recently made public its Departmental Annual Reports (DARs) including R&D expenditure profiles—with the important exception of eight defence-related agencies which have not been required to make public their DARs and which represent 45.2% of central government R&D spending. We are indebted to Yutao Sun and Cong Cao who have compiled and analysed in Science[13] the budgets of key S&T-related ministries and agencies, thereby shedding light on expenditures as a policy tool. The table below sets out the expenditures for both S&T- and R&D-related purposes for selected organisations.

Sun and Cao note that, according to China's delineations of expenditures, there has been a relative decline in spending on basic and applied research and an increase in what they call development (more downstream in the research chain), with a potentially negative impact on China's innovative capability, and the potential to jeopardize its plans to become an innovation-oriented nation.[14]

Figure 2: S&T/R&D Budgets of Key national government organisations in 2011

Source: Adapted from table in RMB developed by Sun and Cao using Department Annual Reports on Financial Budgets and Final Accounts (DARs) at central agencies and central government level

China's Key Central Government Agencies by S&T/R&D Expenditure from Central Appropriation in 2011

(billion USD, February 2015 exchange rate: 0.16)

Agencies	S&T Expenditure	R&D Expenditure				
		Basic	Applied	Development	MEPs	Total
MOST	4.43	0.75	1.42	1.24	0.002	3.41
CAS	3.03	1.33	1.19	0.04	0.07	2.63
NSFC	2.35	2.35				2.35
MIIT	0.99	0.03	0.28	0.004	0.67	0.98
MOE	0.62	0.50	0.07	0.02	0.005	0.60
MOA	0.52	0.04	0.32	0.0006	0.07	0.42
MOH	0.40	0.01	0.10	0.0002	0.25	0.36
NDRC	0.01		0.01	0.0006	0.0002	0.01
71 agencies	14.14	5.05	4.29	1.33	1.13	11.80
Non-disclosed agencies	16.94					9.75*
Central government	31.07	4.71	15.68			21.55*

* These figures are estimated.

Issues in Governance

This suite of organisations is a large and complex group to coordinate, with overlapping mandates and common stakeholders. At the ministerial level, the Leading Group has an important role, but it only meets twice to four times a year to provide broad oversight and take high level decisions, unlike Cabinet committees in Western systems of government which can meet weekly or bi-weekly to provide direction to officials and make decisions. It is certainly true that there is good will and collaborative personal relations at the highest levels of the various ministries and agencies. And as in Canada, the senior appointments process has tried to promote a culture of collaboration through horizontal appointments across ministries and agencies. For example, a current MOST Vice Minister was previously Vice Minister in the Ministry of Education, and vice versa.[15] Nevertheless, an STI system as large and complex as China's cannot rely solely on such mechanisms to ensure coordinated, non-duplicative governance, particularly considering the provincial and local STI players. As we will see below, two new mechanisms, if extended and re-mandated, could serve broader pan-government STI coordination on an ongoing basis.

2. SIGNIFICANT S&T PROGRAMS

Since Deng Xiaoping's Reform and Opening was announced in 1978, the Government of China has implemented over time various national S&T programs to accelerate the development of science and technology. Some programs have created milestones of progress in China's S&T development. The evolution of the programs also reflected shifts in emphasis and more significant changes in policy directions. Most programs have been implemented for more than two decades. The objectives and priorities have changed over time in order to adapt to the needs of the country in S&T. In the review of China's innovation policy, the OECD and MOST have concluded that the R&D programs are the single most important policy instrument in China's S&T strategy.[16]

A number of important national S&T programs have accelerated the development of science and technology in China over the past three decades. They have generally been considered as two categories – the 'core' programs and the programs for environment building, industrialization or commercialization.[17] The three core programs are the National Key

[12] Figure 1 Adapted from: OECD & MOST (2008). OECD Reviews of Innovation Policy: China, p.54; Mu Rongping. *Development of Science and Technology in China*. Available at: http://www.nistep.go.jp/IC/ic040913/pdf/30_04ftx.pdf)

[13] Yutao Sun and Cong Cao, p. 1008.

[14] Ibid.

[15] Kang Qi, Institute of S&T System and Management, CASTED, MOST briefing, Beijing, July 15, 2014.

[16] OECD & MOST, *OECD Review of Innovation Policy: China*, 2008, p. 53.

[17] Hu Hongling, Zhou Ping and Gong Chunhong (2006). Current status and strategy of China's S&T Programs, 2006. 中国科技项目管理的现状与对策. Science and Technology Management Research, and see MOST, http://www.most.gov.cn/eng/programmes1/200610/t20061008_36200.htm

Technology R&D Program (the Supporting Program after 2006), the 863 Program and the 973 Program which have invested in developing technologies to address economic, sectoral (e.g., agriculture) and social challenges, and over the years there has been an increased effort to use the programs to assist companies by financing advanced manufacturing technology development and new materials and techniques for product development. National programs such as the Spark Program and the Torch Program are designed to develop industrialization and commercialization. Others such as the Innovation Fund (or Innofund) for technology-based SMEs and MOST's National Science and Technology Infrastructure Program have also been influential in the formation of a vibrant S&T culture. The flagship programs for basic research have been at the National Natural Sciences Foundation of China (NSFC) and the government has dramatically scaled up its annual investments from $12.3M in 1986 to $3.08B USD in 2014.[18] In addition, talent acquisition initiatives developed by CAS and other ministries and agencies have been in effect since the mid-1990s. All these programs focus on various aspects of S&T development, and were intended to support one another and create a comprehensive national S&T system. A detailed description of each program appears in Appendix 2 of this paper. Together they represent an enormous and growing investment by the Government of China in science, technology and innovation.

At the same time, one cannot help but observe that a large number of programs introduced by multiple agencies, one after the other over many years, usually added on to what was there before, would not result in an easy set of dynamics to manage across the entire national S&T system. It is therefore understandable that the Government of China chose in October 2014 to introduce changes intended to streamline and better manage the system of agencies and programs. How these changes will be operationalized is yet to be seen in detail, and making extensive changes across such a wide system is daunting to say the least. Indeed, those who have worked within the counterparts to China's Organisation Department and State Council Office, advising Prime Ministers and Presidents on significant organisational change, such as the Machinery of Government Secretariat of Canada's Privy Council Office, have a strong reluctance to make major organisational changes unless there is a serious problem crying out for reform. It can take five or more years for organisations and their stakeholders to adjust to changes of governance or program reorganisation. And in a country as large and complex as China, the challenges can be magnified hundreds of times. Figure 3 is a depiction of programs as they were introduced, culminating in the suite of new program categories announced in October 2014.

[18] NSFC budget for 2014 available at: http://www.nsfc.gov.cn/publish/portal0/xxgk/tab214/info40355.htm
NSFC budget for 1986 available at: http://www.nsfc.gov.cn/nsfc/cen/jgsz/index.htm

Figure 3: National Catalytic Programs

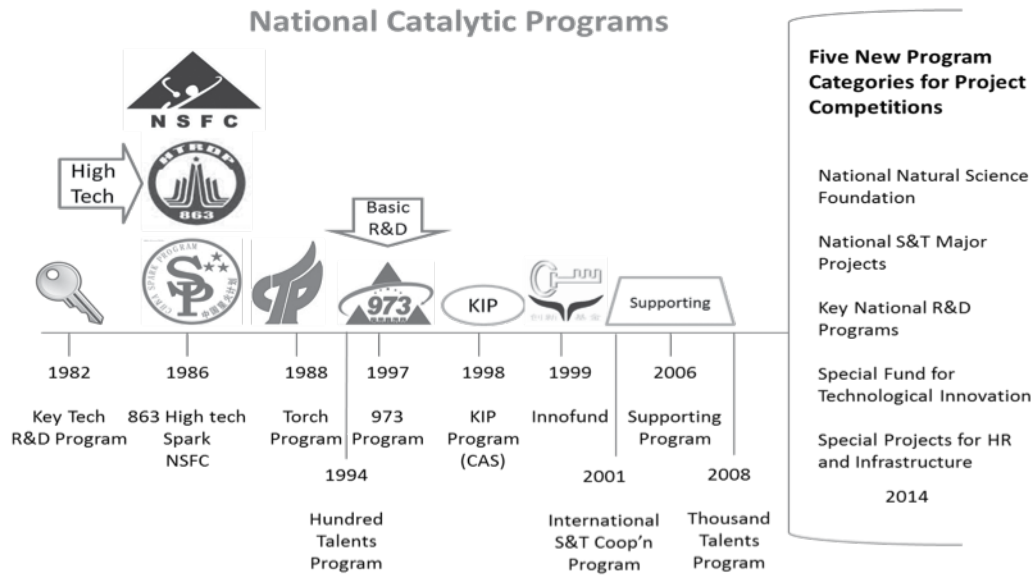


Figure 4: Period during which each program has been in force
Notes: Shadowed areas = period in force
Supporting Program replaced Key Tech program in 2006
'Innovation 2020' became the new form of KIP in 2010
Sources: ERAWATCH, MOST and OECD

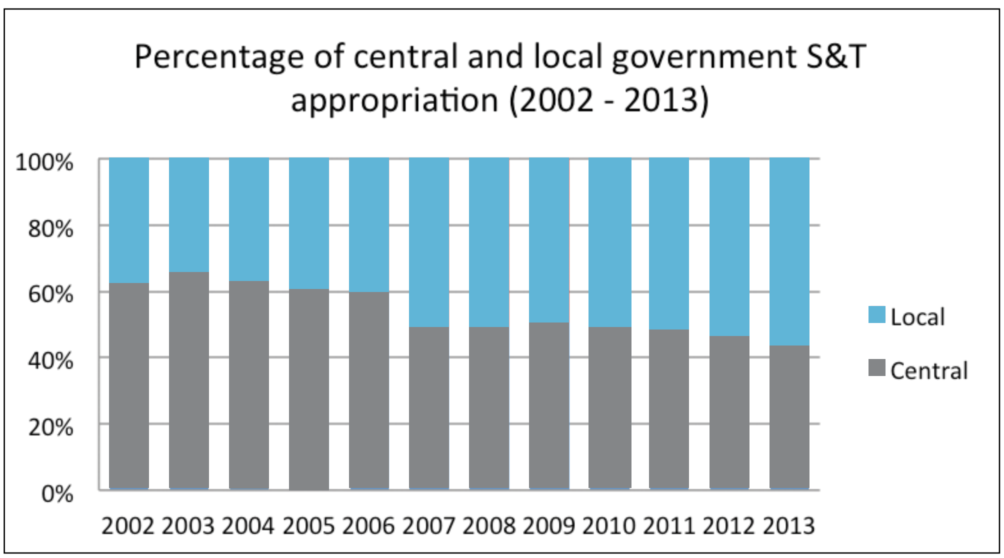
Programs	Started	Major Agency	1981-1985	1986-1990	1991-1995	1996-2000	2001-2005	2006-2010	2011-Present
Key Tech Program	1983	MOST							
863 Program	1986	MOST							
NSFC Funds	1986	MOST							
Spark Program	1986	NSFC							
Torch Program	1988	MOST							
Hundred Talents Program	1994	CAS							
973 Program	1997	MOST							
Knowledge Innovation	1998	CAS							Inno 2020
Innofund	1999	MOST&MOF							
Int'l S&T Coop'n	2001	MOST							
R&D Infrastructure	2005	MOST							
2006-2020 MLP	2006	MOST							
Supporting Program	2006	MOST							
National Major Projects	2006	MOST							
Thousand Talents Program	2008	Multi-agency							

Figure 4 is a chart of the most significant programs in place in 2014, with their responsible agency indicated and a timeline as to when they were put in place over the years.

The programs were introduced to develop technologies to respond to China's domestic needs and to narrow the gap with industrialized countries in science and technology. Significant funding of $190.5B USD (2012) is allocated to R&D activities from all sources in China including all levels of government as well as private sector industry. Of this, 70% or $133.4B USD came from business including State Owned Enterprises (SOEs), 21.6% or $41.1B USD came from government S&T programs ($30B USD at the national level), and 8.4% from other sources.[19]

One important trend in the past ten years is that, while the absolute RMB/USD expenditures on R&D by all levels of government is increasing, the percentage share of provincial and local levels of government expenditure is increasing proportionately while the central government's expenditure share is decreasing.

Figure 5: Percentage of S&T expenditures at the central level of government, compared to local/provincial[20]



[19] Data from MOST statistical bulletin 2013, p. 5. In Chinese only. 2013 年全国科技经费投入统计公报. Available at: http://www.most.gov.cn/kjtj/tjbg/201411/t20141102_116442.htm

[20] Source of data: MOST Statistical Bulletin 2013, p.5 (in Chinese only) and China S&T Statistics Data Book 2013, Available at www.sts.org.cn .

In terms of performance of R&D in 2012, 76% was performed by business, 15% by research institutes, and 7.6% by higher education organisations such as universities.[21] The *flow* of the funding is also interesting, particularly expenditures by companies which are providing significant stimulation to R&D in other organisations. For example, in 2012 the share of external expenditures on R&D by enterprises to domestic research institutions (such as CAS institutes) was 40.5%, and the share to domestic higher education organisations was 20.5%; the share of external expenditures by research institutions to domestic higher education was 12.4% and the share to other domestic research institutions was 66.4%.[22]

Issues in S&T Programming

Various approaches have been applied in stimulating the development of science and technology—from high-tech funding to basic R&D investment; from earlier rural application of S&T to funding for SMEs in order to trigger innovation. The evolution of national S&T programs explains how the priorities were adjusted according to national strategies in different times (for the implementation period of programs, see Figure 4). However, challenges remain in policy implementation. For instance, the national programs were usually launched to meet the changing demands in S&T development. As the conditions of science and technology have evolved over time, it has been an issue to distinguish and make the most of various programs. One of the major criticisms is that "973 is similar to 863, 863 is similar to Key Technology R&D"[23] and in turn, there has been a perceived problem of the misallocation of research resources.

This is reminiscent of the problems identified in Canada's S&T programs in the early and mid-1990s which led to Canada's largest wholesale change in its suite of S&T programs. Companies at that time complained to Canadian Cabinet Ministers that the large array of small and medium-sized programs was confusing, overlapping, and in some cases too narrow so that companies fell between programs which did not fit the criteria for any of them. Ministers did away with almost all programs at that time as a cost-cutting and streamlining initiative, and then set up one large program—Technology Partnerships Canada (TPC) that covered all sectors and in particular large and medium-size companies while the Industrial Research Assistance Program (IRAP) continued for SMEs. TPC years later ran afoul of WTO rules, and was ultimately replaced by other programs focussed on automotive and aerospace sectors in particular, but IRAP continues and has recently been enhanced in it role and funding levels.

In China, key agencies and line ministries such as NDRC, MOE and MIIT have important roles to play in S&T programming. However, China's flagship S&T programs have been the responsibility of MOST, CAS, and NSFC. The challenge of coordination

[21] Ibid. Note that the percentage figures cited in the document add to 98.6% rather than 100%, without explanation for the 1.4% balance, possibly due to rounding.
[22] Ibid.

[23] Wang Futao (2006), Observe China's S&T Development in Universities from the achievement award of 863 Program. In Chinese only: 从 "863计划 "成果获奖情况看我国高校技术发展状况. "973像 863, 863像攻关". The critics pointed to problems in the S&T programs. From the applicant's point of view, the lines between the programs are very vague. Available at: http://image.sciencenet.cn/olddata/kexue.com.cn/upload/blog/file/2009/1/20091121131880717.pdf Source paper in Chinese only.

across all agencies and ministries has been identified for some time, and is at the core of the current move to reform S&T governance and programming in China. For example, in 2006 Professor Wang Futao of the South China School of Technology suggested that an important purpose of the 863 program was to concentrate distributed research resources and to coordinate research sectors in order to magnify single innovations into a collective innovation. However, in the actual implementation, he suggested that little collaboration has taken place among the various institutes, and many research agencies were neither effectively maximizing the use of resources from the program nor taking it as a platform to cooperate with others.[24]

In addition, the funding of S&T programs has been problematic. Despite budget figures being recently made available for ministries and agencies, annual budget figures per program are not uniformly available or transparent. Numerous program budgets are fungible in that they may be allocated to one program area, enterprise or institute and then be moved to another; such flexibility can be excellent in responding to innovation opportunities, but without a good tracking system it is difficult to get a clear picture of program budgets. Again, the reform process launched recently will review the base budgets of all programs and determine what is required in the new program configuration; ultimately the intent is that the government will report in a more transparent manner.

[24] Ibid, pp 68-69.

In addition to the increased coherence and coordination across programs which is the key aim of Xi Jinping's new changes, there are concomitant opportunities to address the weaknesses in the current suite of programs. A case in point is the 863 program which, despite its successes in fostering research and translating key technologies to market, has not been successful in achieving all targets. For example, the signature elements of 863 Program are "originality and innovation", to replace China's tracking and imitation approach, but the fact that there was no winner for the First Award of State Technological Invention for six consecutive years (1998 – 2003) brought concerns to the attention of policymakers that the program was not investing in a world-leading level of innovation.[25] Clearly there is an opportunity to raise the bar of excellence in this and other programs as part of the new program review.

[25] Ibid, pp. 67-69.

II. STRATEGIC DIRECTION

The Medium- To Long-Term Plan and S&T Performance

Since the 1950s, China's governments have been managed by a series of national Five Year Plans. Each one has had dimensions related to S&T which has become more important in consecutive plans over the decades, and this has provided signals and direction as to government priorities and plans for S&T investments. In addition, multi-year long term plans have been put in place since 1956 when the first one focussed on priorities such as atomic energy, missiles and semiconductors; they have been adjusted as necessary within the 10 to 15 year period, for example during periods of change such as the Cultural Revolution. Over time, these strategic plans have been credited in China with their success in developing nuclear weapons and satellites, manned spaceships, hybrid rice, and high performance computers. But until two years ago, they have not been systematically and independently evaluated.[26]

In 2006, the State Council issued the eighth Medium to Long-term Plan for the Development of Science and Technology (2006-2020) (hereinafter the MLP) which aims to push China to become an innovation-oriented society over a 15 year period. The Five Year Plans continued, but were tailored to fit the broader directions reflected in the MLP. The preparation of the MLP involved a massive two year open consultation process involving more than 2,000 scientists, engineers, economists, corporate executives and even foreign experts who identified the critical problems and research opportunities facing China. The deliberations then moved to the internal government bureaucracy where 20 working groups further refined the priorities, eventually involving the engagement of Premier Wen Jiabao as Chair of the Leading Group.[27]

The 65 page, comprehensive MLP identified eleven key S&T priority sectors: energy; water and

[26] ATIP and Liu Li, p. 6.

[27] Cong Cao, Richard P. Suttmeier, and Denis Fred Simon, "China's 15-year science and technology plan" in *Physics Today*, American Institute of Physics, December 2006, p. 38.

mineral resources; the environment; agriculture; manufacturing industry; transportation sector; information industry and modern service industry; population and health; urbanization and city development; public security; and national defence. In addition, it identified what it called "Frontier" technologies, which in some jurisdictions are called "enabling" technologies: biotechnology; information technologies; advanced materials technology; advanced manufacturing technology; advanced energy technologies; marine technology; laser technology; and aerospace technology. Specific basic research areas were described (e.g. core mathematics and physical laws at a cosmological scale), along with "major special projects" that can help China leap-frog to a higher level of technology development. Finally, the MLP mapped out a plan for a new National Innovation System, as well as new policies (e.g. to encourage indigenous innovation and improve the rigour of the intellectual property system) and a higher profile for S&T infrastructure and programs to increase the development of highly qualified personnel (HQP).[28] National Megaprojects introduced in the MLP have involved substantial government investments and incentives for key technology and engineering projects with commercial applications.[29]

Up to that point, MOST had controlled most of the established national S&T funding programs along with CAS and NSFC. With the MLP, other agencies were given additional responsibility for delivering S&T or STI programs and initiatives and supporting the comprehensive policy overall, including NDRC, MOF, MOE and MIIT.[30] In the market-oriented environment, business sector was to be the key driving force for innovation.

The MLP plan also highlighted several key objectives for the long term agenda of S&T so as to position China as a world S&T power by 2050: mastering core technologies in manufacturing and IT; leading in agricultural technologies; achieving technological breakthroughs in energy; among others. Furthermore, specific quantitative targets for 2020 were established:

- Increase R&D intensity significantly to 2.5%;
- Rate of S&T contribution to the economy to reach at least 60%;
- Dependence on imported technology to decline to 30% or below; and
- Patents granted to Chinese nationals, and international citations of scientific papers to move China into one of the top 5 countries.[31]

The target of 2.5% was an aggressive one when it was set in 2006, as it is a significant leap from 1.34% in 2005. It is looking more realistic now given performance of 1.98% in 2012[32], though as we are now seeing, unexpected economic changes can impact it. Indeed, Canadian Prime Minister Brian Mulroney announced in the 1980s that he would set a 2.5% intensity target, but the amount of government expenditure that would have entailed was significant. $1.5B over five years announced in 1987/88 brought

[28] State Council, *The National Medium- and Long-Term Program for Science and Technology Development (2006-2020)*, Beijing: 2006.

[29] Springut, M., Schlaikjer, S., & Chen, D. *China's Program for Science and Technology Modernization: Implications for American Competitiveness*. U.S.-China Economic and Security Review Commission. Washington, DC, 2011.

[30] Schwaag-Serger, S., & Breidne, M. "China's Fifteen-Year Plan for Science and Technology: An Assessment" in Asia Policy , 4, 2007, pp. 135-164.

[31] *MLP*, p.12.

[32] Ministry of Science and Technology, *National Innovation Index Report 2013*, Beijing: CASTED, Scientific & Technical Documentation Press, 2014, p. 10.

Canada's intensity of R&D expenditures from 1.19% to only 1.35%—nowhere close to his target—and Prime Minister Mulroney eventually concluded that "targets are traps". Once committed to an aggressive target, it is politically unpalatable to fail to succeed. In China, the levers of the state are stronger and more pervasive than in Canada, but there is still a huge expenditure involved in a 2.5% target. In China, it will rely heavily on private industry investing in R&D, as government expenditures, as indicated above, are only 21.6% of overall R&D expenditures in China.

The direction to strengthen indigenous or "homegrown" innovation is a very important distinction in the 2006 MLP. For the previous 25 years, China's policy had been to increase technology transfer from Western countries to bring the technology of the country as close as possible to Western standards. Hundreds of MOUs signed with other countries and S&T agencies were designed to improve China's industrial strength, expose their researchers to advanced technology and accelerate their own R&D. There is still a lot happening on that front, but massive investments in China's HQP, S&T infrastructure, R&D centres of excellence, and enabling industrial technologies have begun to demonstrate real progress in some of the most important areas of science and technology. In some fields, China is in the vanguard thanks to strategic and high level investments. And its people power is truly impressive. R&D personnel fulltime equivalents in 2014 were 3.25 million person years (PYs); the MLP target for 2020 is 4.3 million PYs and China is now running ahead of the numbers to meet that target.[33]

The government has signalled that the private sector will be expected to do more. Its share of R&D is significant, and large China-based corporations are trying to demonstrate that they are performing independently of government in their strategies and investment decisions. Indeed, given Western expressions of angst about their possible hidden intentions in buying all or parts of foreign companies and resources, they have been at pains to differentiate themselves from the Government of China and ministerial activities, protecting both their independence and the appearance of independence. For example, according to MOST officials, some large companies strongly discourage Ministers and other senior officials from visiting their facilities[34], unlike in Canada, where Ministers often visit Canadian companies or MNEs for program or funding announcements and are regularly welcomed to see their latest technology developments. For Chinese companies, expected under the MLP to carry the main load on innovation, there remain significant barriers to their performance, most particularly hiring large numbers of HQP with innovative instincts and who are willing to take risks. This is one of the prime barriers which companies identify regarding their innovation capacity.

The MLP is not a rigid and static directive. The government is aware of the nature of science and technology, and according to an interview conducted by Schwaag-Serger and Breidne with government officials in 2006, officials said that "just because we have set goals does not mean we cannot change them."[35] Indeed, as we will see below, seven years into the MLP, the government undertook a comprehensive review including focussed consultations with foreign S&T experts on the strengths and weaknesses of the strategies reflected in the MLP and the S&T programs overall, and changes were made. The five year plans continue, but are tailored to fit the broader priorities identified in the MLP.

[33] Kang Qi, Institute of S&T System and Management, CASTED, MOST briefing, Beijing, July 15, 2014.

[34] Ibid.

[35] Sylvia Schwaag-Serger and Magnus Breidne. "China's Fifteen-Year Plan for Science and Technology: An Assessment." *Asia Policy*. No. 4, July 2007, p.162.

III. PERFORMANCE IMPACTS

The Dramatic Growth of Science and Technology as a Driver of the Economy

With the governance arrangements described above, plus comprehensive S&T program support, and focussed planning and priority direction from the top in Five Year Plans and now the MLP, what has been the impact on the economy of China? Without exception, one can see a dramatic increase in virtually every measure of investment in innovation and the development of highly qualified personnel (HQP). But this does not mean that all variables have had the success that the leadership was pursuing. Moreover, the way that the Chinese government collects statistics has been criticized as not completely reliable.

1. OVERALL RANKING OF CHINA'S NATIONAL INNOVATION

Since 2006, China has had in development a National Innovation Index by which it could compare its own progress against that of the top 40 countries with the best innovation performance, representing over 98% of global expenditure on R&D. For four years, the National Innovation Index Report was published in Chinese.[36] In 2014, the Minister of Science and Technology decided to have the report translated into English so that it would be more accessible to Western governments, businesses and researchers.

The public release of the 82 page English translation of the National Innovation Index Report 2013 is anticipated in the near future. The Ministry of Science and Technology is managing the statistical survey processes as well as the monitoring and evaluation of innovation capability. There are 20 quantitative and 10 qualitative indicators, with some adjustment of the measures over time as officials assessed the Index itself in operation. Figure 6 below describes the variables of China's innovation index.

[36] Ministry of Science and Technology, *National Innovation Index Report 2013*, Beijing: CASTED, Scientific and Technical Documentation Press, 2014. The report assesses variables up to and including 2012, but was published in Chinese in July 2014 and it is expected to be released in English in 2015. The Chinese report can be found at: http://www.most.gov.cn/cxdc/cxdcpjbg/ . The English translation is not yet available except directly through MOST officials. The graphs below are at pages 69 and 74 respectively.

Figure 6: Innovation Index Indicators

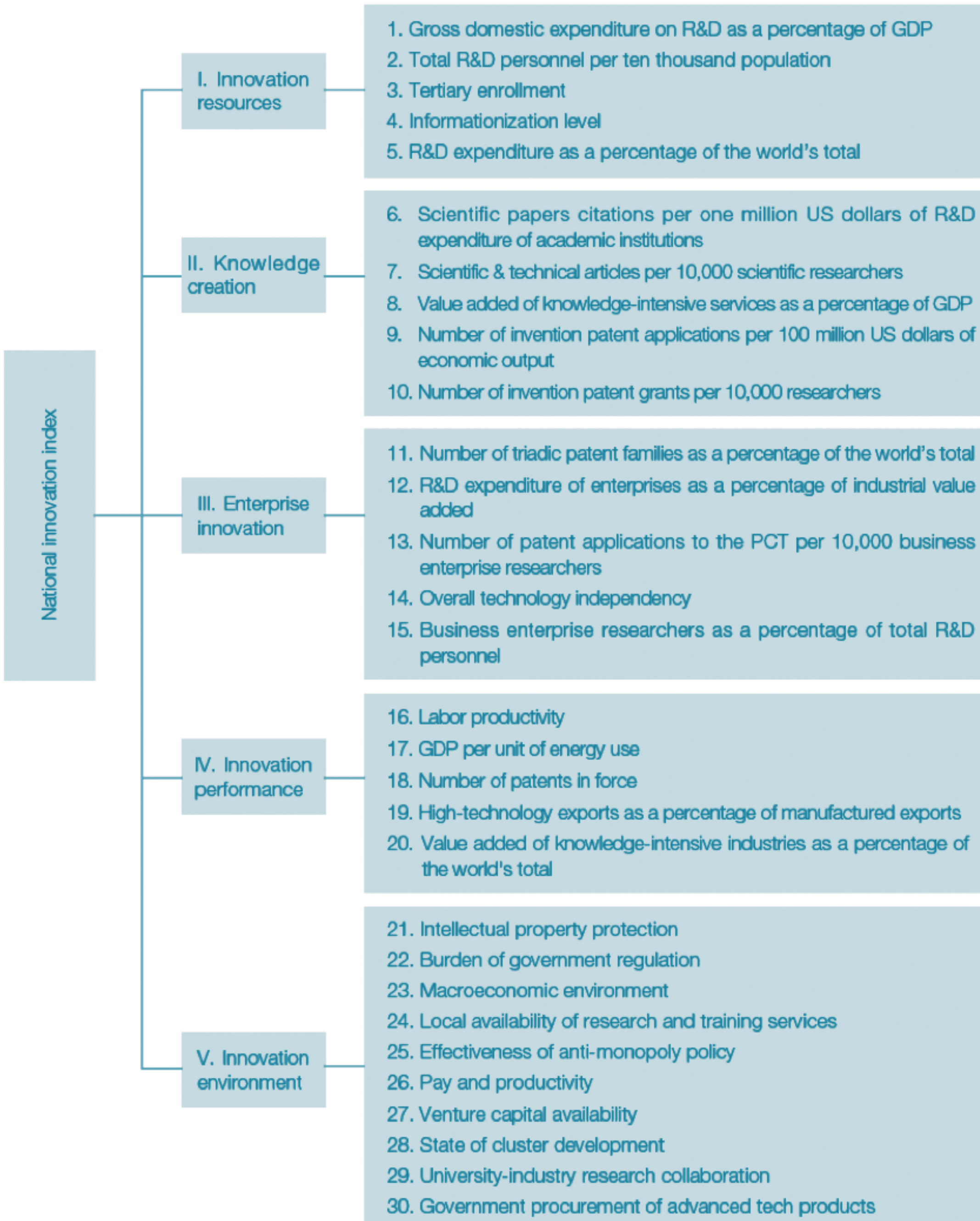
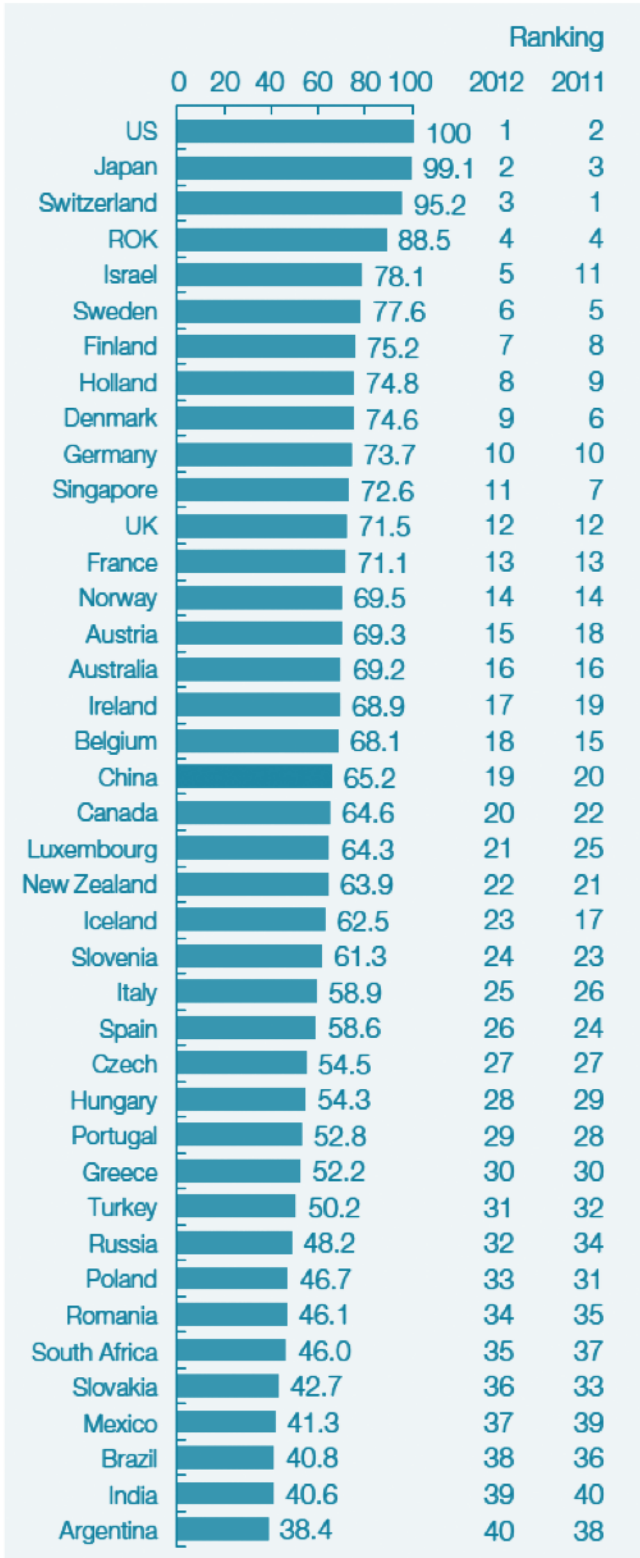


Figure 7: Chinese Innovation Index Rankings



China's overall ranking in the 2013 Index Report, covering the years up to and including 2012, the most recent assessment year, is 19 out of 40, up from a 38th ranking in 2000 and a 25th ranking in 2005. (Canada appears at a 2012 ranking of 20.) At the same time, fluctuations seen within some of the measurements themselves must be considered and clarified. These fluctuations can be seen in the detailed year over year assessments on each of the thirty factors attached as Annex 3 to this paper. Statisticians and economists can be expected to call for transparency in how some of the rankings have been arrived at. MOST will need to engage with other countries as to how the rankings have been derived and the specific sources used in each case. In the interim, statistics and associated rankings should be referenced where verified in public sources.

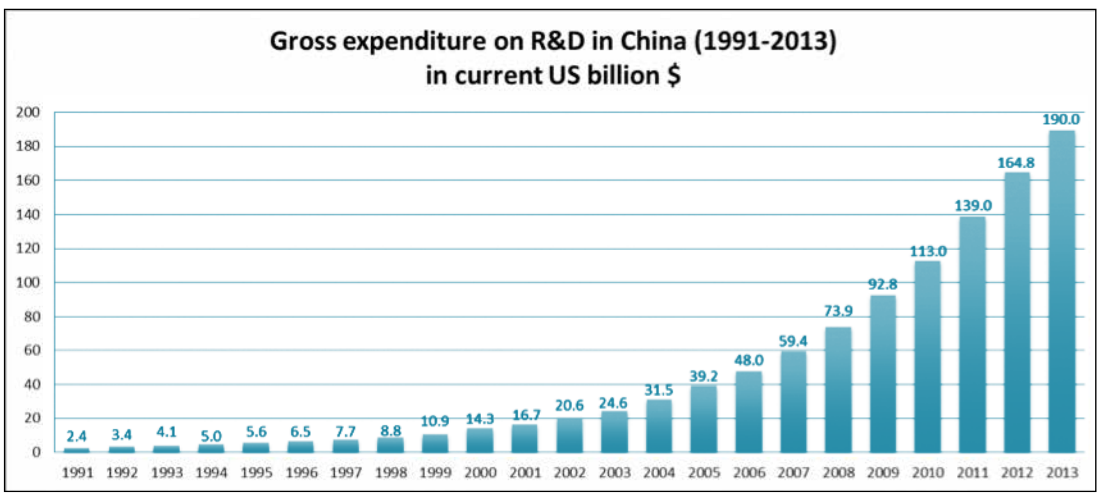
One disheartening factor for Canadian reviewers of the Index is that Canada rates barely a mention. It appears on graphs comparing all 40 countries, and in the text pointing out that China is just ahead of Canada, Luxemburg and New Zealand, and that Canada and certain other nations have slowing growth in R&D expenditures.[37] Throughout the document, Canada's innovation strengths do not figure at all—China is measuring itself against the US, Israel, South Korea, Japan, Germany, France, and sometimes the other BRICS countries. Canada is not on China's innovation radar as a model or partner for China; why would China want to benchmark itself against a country that is lower than itself in the Innovation ranking? To be sure, China does want to partner with Canada in certain key areas of R&D. However, Canada's continuing poor performance on innovation, documented in many reports and assessments, will be a huge challenge for the future if Canada wants to partner with an increasingly innovative China to access its R&D capabilities, not to mention as a continuing platform for a stronger trade relationship.

[37] Ibid, pp 4, 15.

2. EXPENDITURES ON RESEARCH AND DEVELOPMENT

R&D expenditure plays a very important role in enhancing a country's competitiveness and economic growth.[38] According to the OECD, the main aggregate used for international comparisons of R&D expenditures is Gross Domestic Expenditure on R&D (GERD).[39] China's investment in R&D has maintained a significant growth rate in the past decade. Figure 8 shows the annual growth rate in R&D expenditure from 1999 to 2013. China's reported gross domestic expenditure on R&D was $2.4B current USD in 1991, while by 2013 this number had increased to $190.0B current USD, bringing China to third place behind the US and Japan. The growth in these absolute numbers demonstrates the effort that China has put into R&D as an investment in economic development.

Figure 8: Gross expenditures on R&D (GERD) in China (1991-2013), NBS of China[40]



[38] Ma Mingjie, & Shi Guang. (Oct.29, 2013). *International experience and inspiration of the relationship between R & D investment and economic growth* (in Chinese only). The authors are officials of the Development Research Center of the State Council. For the original document see: http://edu.drcnet.com.cn/eDRCnet.common.web/DocSummary.aspx?chnid=1002&leafid=1&docid=3377314&uid=0201&version=edu

[39] OECD. (2011). *OECD Science, Technology and Industry Scoreboard 2011: R&D expenditure.* See: http://www.oecd-ilibrary.org/sites/sti_scoreboard-2011-en/02/05/index.html?itemId=/content/chapter/sti_scoreboard-2011-16-en

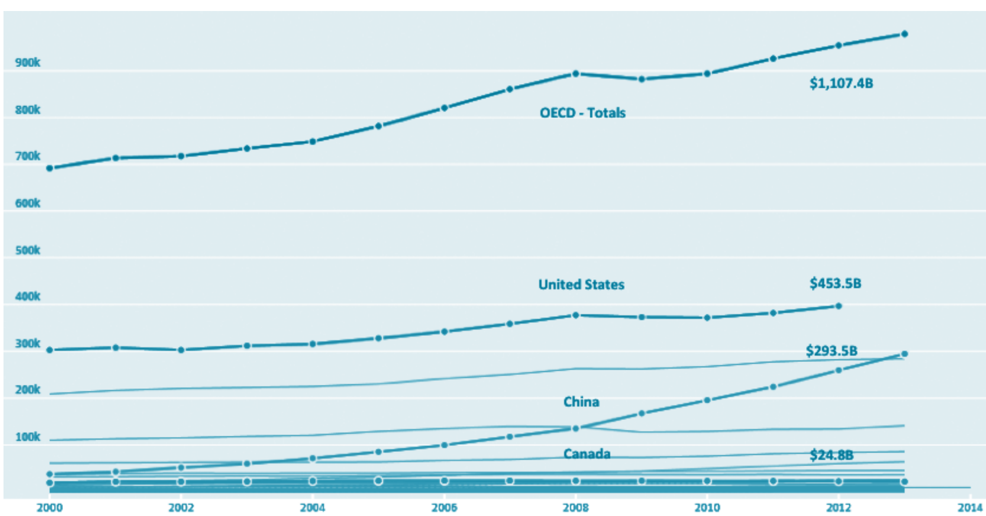
[40] Source of data: Statistical Bulletin of National S&T investments, National Bureau of Statistics of China. See: http://www.stats.gov.cn/tjsj/tjgb/rdpcgb/qgkjjftrtjgb/

At the same time, while OECD statistics of the same measure show the same dramatic growth in spending on R&D, the absolute numbers used by OECD are based on purchasing power parity (PPP) in order to compare effectively across all economies, and are therefore much higher for China. Specifically, the graph at Figure 9 shows that total OECD countries' expenditures on R&D in 2012 are at $1,107.4B, while the US' are at $453.5B and China's are at $293.5B. In comparison, Canada's are at $24.8B for 2012.

Given that China's GDP also experienced tremendous growth in the same period, the increase in absolute expenditures may not be the best indicator of its performance in R&D. R&D expenditure as a percentage of GDP, also known as R&D intensity, is used as "an indicator of an economy's relative degree of investment in generating new knowledge," according to the OECD.[42] This indicator is widely used to compare the effort of nations in R&D development. Figure 10 compares the R&D intensity of China and Canada—there was a significant difference between Canada (1.65%) and China (0.57%) in 1996. However, by 2012, China had reached 1.98% and exceeded Canada's R&D intensity of 1.74%. Then in 2013, China moved ahead again to 2.08%; numbers for Canada's GERD/GDP ratio in 2013 are not yet available. In summary, China increased its R&D expenditure performance remarkably, not only in gross R&D expenditures but also in intensity investment.

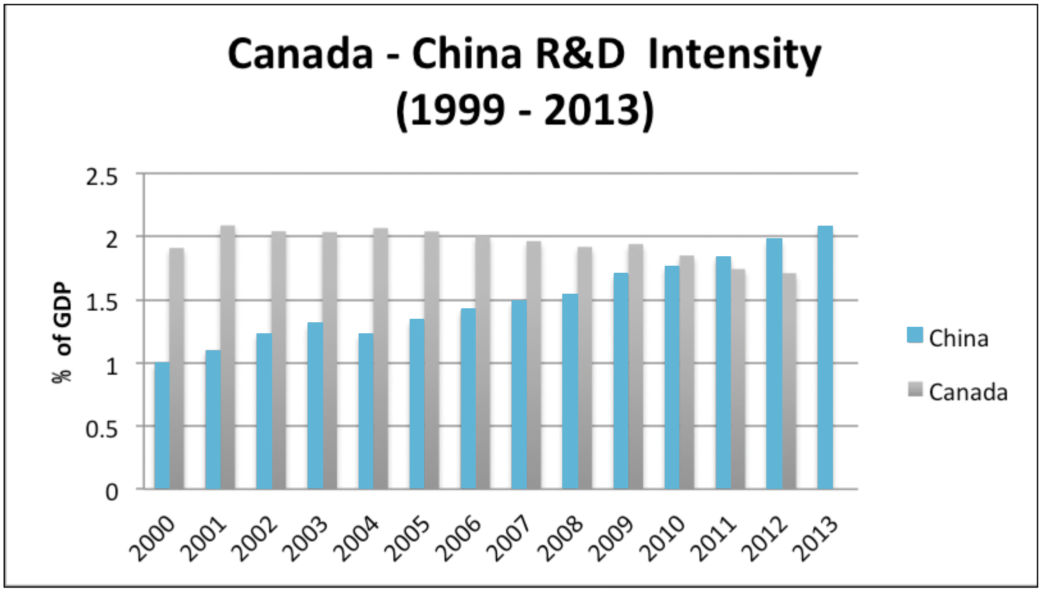
The type of research conducted through these expenditures is also an important factor in providing a strong base for innovation. In China, basic research is now funded at only 4.7% of expenditures,[43] an amount which will need to increase if the country is to achieve more significant value for the financial resources allocated for R&D.

Figure 9: Gross expenditures on R&D (GERD) in China (2000-2012), OECD[41]



[41] OECD (2015) Gross domestic spending on R&D (indicator). Doi: 10.1787.d8b068b4-en February 3, 2015. Available at http://data.oecd.org/rd/gross-domestic-spending-on-r-d.htm (and link to GERD).
[42] Ibid.
[43] Kang Qi, Beijing, 2014.

Figure 10: R&D expenditure as a percentage of GDP (R&D intensity)[44]



Ma Mingjie and Shi Guang of the Development Research Centre of the State Council Office have pointed out that a country's competitiveness is closely related to its investment in R&D. Consequently, maintaining this strong trend will be critical to China's future competitive performance.[45] While China is still behind countries such as the US (2.77%), Germany (2.82%) and Japan (3.44%),[46] the significant progress that China has made places it far ahead of many other developing countries[47] —if indeed it can still be seen as a developing country. In addition, the MLP has set a target for China's R&D intensity of no less than 2.5% in 2020.[48] China has been keeping this momentum for more than a decade and it has the ambition to further improve its performance.

A factor related to expenditures on R&D is the number of R&D personnel a country has. China ranks first in the world for the fifth consecutive year with 3.247 million fulltime equivalents (FTEs) in 2012, of a total of 11.107 million R&D personnel in the world, giving China 29.2% of the world total.[49]

[44] Source of data: World Bank Indicators, Source of data: World Bank Indicators. Research and development expenditure (% of GDP). Available at: http://data.worldbank.org/indicator/GB.XPD.RSDV.GD.ZS. And the Bureau of Statistics of China http://www.stats.gov.cn/tjsj/tjgb/rdpcgb/qgkjjftrtjgb/

[45] Ma Mingjie and Shi Guang. "International experience and inspiration of the relationship between R & D investment and economic growth" (in Chinese: 研发投入与经济增长关系的国际经验和启示), October 29, 2013. Available at: http://edu.drcnet.com.cn/eDRCnet.common.web/DocSummary.aspx?chnid=1002&leafid=1&docid=3377314&uid=0201&version=edu

[46] Data from the World Bank (2011). Research and development expenditure (% of GDP). See: The World Bank: http://data.worldbank.org/indicator/GB.XPD.RSDV.GD.ZS

[47] Wu Yanrui. (2012). Trends and Prospects in China's Research and Development Sector. Australian Economic Review, 45 (4), 467-474.

[48] MOST, *National Medium- and Long-Term Program for Science and Technology Development*, available at http://www.most.gov.cn/kjgh/kjghzcq/

[49] MOST, *National Innovation Index Report*, 2013, pp 4–5.

Within these figures, however, some have criticized the precise areas of R&D investment, and the research focus of R&D personnel. For example, in January 2014 UK-based science journalist Richard Van Noorden noted that China had for the first time overtaken the collective GERD/GDP of the 28 EU member states which stood at 1.96% in 2012, but pointed out that "China's emphasis on applied and product-development research means that funding for basic science remains low: only 5% of the country's total R&D is devoted to this, compared with 15–20% in other major OECD nations." According to Lan Xue, Director of the China Institute of Science and Technology Policy at Tsinghua University in Beijing, researchers who receive low basic pay often take on additional short term projects for industry, but this can distract from their focus on fundamental science problems.[50] Such problems related to the focus of expenditures on R&D form the basic impetus for the recent changes that the Government of China has introduced in their policy, program and organisational structures. These will be discussed in more detail in connection with the Governance changes described below.

3. INDUSTRIAL STRUCTURE

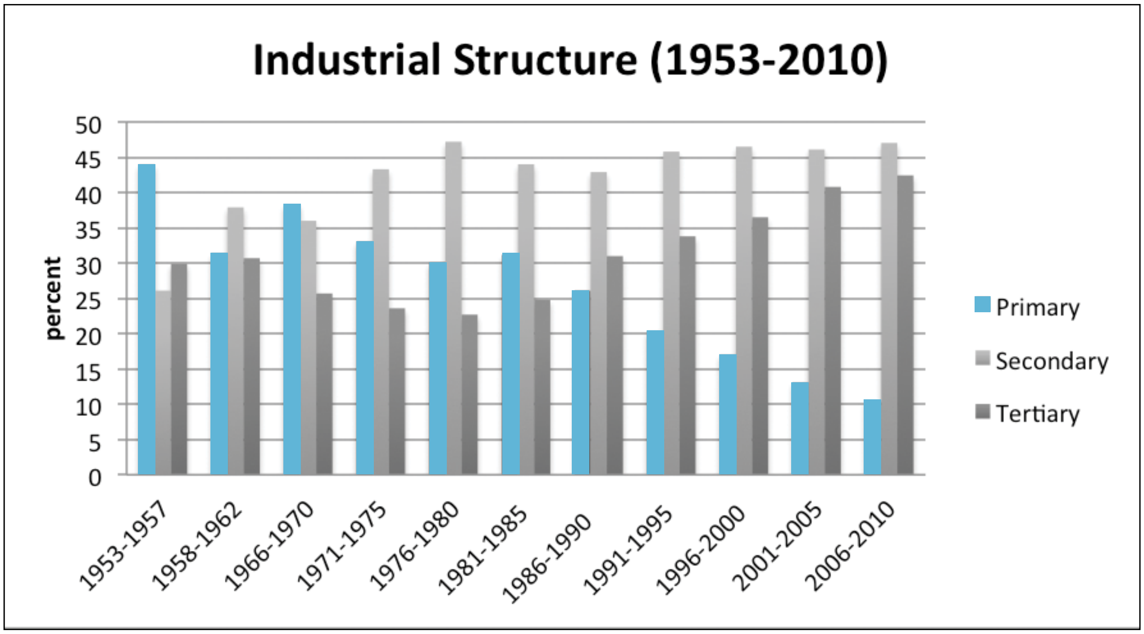
China has adopted unique industrial policies since the 1980s. With an economy very heavily driven by centralization and government ownership and control, at least until the late 1990s, the effectiveness of this approach has been debated and the government has loosened controls and encouraged private sector development in recent years. The changing industrial structure has tracked the changes in policy measures introduced in the economy over the past three decades.

Figure 11 shows that the importance of primary industry has decreased, with some fluctuations in the period up to 1985. Secondary and tertiary industries also experienced fluctuations in the same period. From 1986 to 1990, however, the changing trends of each industrial sector were relatively stable—a continuing decrease in primary industry and an increase in secondary and tertiary industries. In 2013, the proportion of secondary and tertiary industries broke even—both reached 43%. Within secondary industry, according to the National Innovation Index, in 2012 the value-added of China's advanced technology industries accounted for 24.5% of the world's total, ranking second globally for the sixth year, and closing the gap with the US. Domestically, the percentage of advanced technology industries in the value-added created by the manufacturing sector also increased from 9.6% in 2000 to 15% in 2012. The Report concludes that China is gradually moving from a major manufacturing country into a "smart manufacturing power".[51]

[50] Richard Van Noorden, "China tops Europe in R&D intensity", in *Nature*, January 8, 2014. See: http://www.nature.com/news/china-tops-europe-in-rd-intensity-1.14476

[51] MOST, *National Innovation Index Report 2013*, p.11.

Figure 11: Changes in Industrial structure (1953-2010)[52]



The changes in industrial structure also show that the influence of the service industry on the nation's economy is becoming more and more significant and is gradually surpassing that of traditional industries. China's global share of the value-added of the knowledge service industry has grown from 2.7% in 2000 to the current 8.8%.[53] The growth of the service sector more generally is significant in the context of how the service sector is treated with respect to R&D—elements of this sector are often not adequately captured, or indeed resourced, in the context of investment in R&D or in the development of more advanced technologies that can increase efficiencies in the service sector, thereby facilitating the growth and development of the primary and secondary sectors as well.

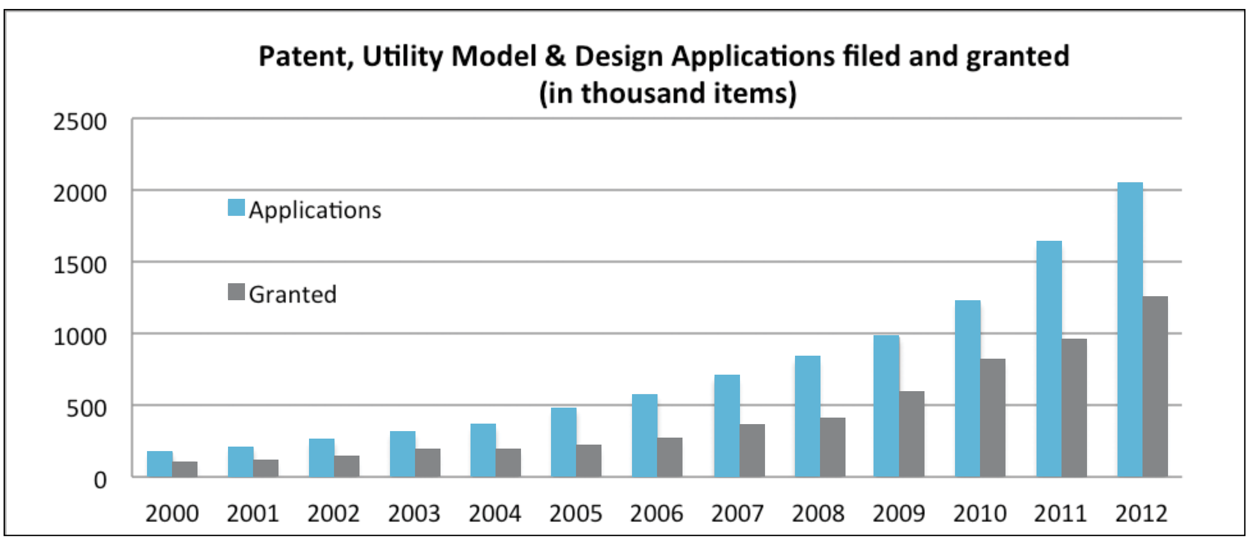
[52] Data collected from the Statistics website Qianzhanwang: http://d.qianzhan.com/xdata/detail?d=xCxlxvyMxX&di=x5xpxoyKxZxlxvyMxX#

[53] MOST, *National Innovation Index Report 2013*, p. 11.

4. PATENTS AND CHINA'S STATE INTELLECTUAL PROPERTY OFFICE (SIPO)

The volume of patents generated in a nation is considered to be an important indicator of innovation. During its first several decades, the PRC, like many other nations in their early years of development, copied the technologies of other countries as an industrial strategy. Even in the 1970s, the government was opposed to establishing an IP regime and there was no respect for IP on which to base it. With Reform and Opening, the Government of China became a member of the Paris Convention for the Protection of Industrial Property in March 1985, and the first patent was protected in 1985. In the first 20 years, 500,000 patents were protected, primarily granted to inventors and companies from around the world. In the following years, more and more Chinese innovators were having patents granted, and by 2012, 144,000 domestic resident invention patents were granted, accounting for 22.3% of the world's total, behind only Japan.[54]

Figure 12: Patents for Inventions, Utility Model & Design Applications filed and granted (in thousand items);
Source: SIPO



[54] Ibid, pp 7-8.

According to SIPO, due to China's efforts in building a more complete Intellectual Property Registration system, the quality of approved patents has been gradually improving with the growth in overall numbers.[55] However, other commentators, such as Cong Cao of the University of Nottingham, assert that the large numbers of patents both filed and granted belies the ultimate impact since many are not ultimately used.[56] A recent study by Thomson Reuters entitled China's IQ (Innovation Quotient) documents that between 2010 and 2013, Chinese firms filing for patents nearly doubled, while in the US and Japan the level of filings held steady. The study points to the government target under China's National Patent Development Strategy of 2010 that local firms are expected to apply for 2 million patents for inventions, utility models and designs by 2015, and it has already met that goal. It is primarily local firms that are responsible for the significant upswing in patent applications. Furthermore, patents filed with foreign patent offices are often subjected to more rigorous review, but only 5.3% of patents filed by local firms in China in 2013 were also filed with foreign patent offices compared with 36% of Japanese local firms and 51.1% of US local firms filing in other countries.[57]

With the dramatic increase in patents granted in China has come a similar increase in the amount of litigation in China's specialized IP courts—primarily Chinese litigants against other Chinese. Indeed, China has become the most litigious country in the world with respect to IP, with 42,902 cases in 2010, of which copyright cases were 24,700, trademark cases were 8,460, and patent cases were 5,785. In comparison, the US had 6,578 total for all three categories.[58] Richard Suttmeier points out that China's system has come a long way given that it was established only in the 1980s, and it is moving towards greater harmonization with other countries in terms of its statutes and the performance of its courts, but IP culture respecting software and overall widespread piracy continue to be a problem. Moreover, an internationally harmonized IP system is unlikely to be truly rigorous in a country where the concept of rights is so weakly established and the rule of law is hostage to politics.[59]

In addition, other governments have regularly criticized China as foreign IP continues to be subsumed or adopted without compensation by Chinese companies. Strong statements include those by then-US Treasury Secretary Timothy Geithner that "They [China] have made possible systematic stealing of intellectual property of American companies and have not been very aggressive to put in place the basic protection of property rights that every serious economy needs over time."[60] This is one of the key challenges for foreign companies hoping to develop trade opportunities in China, and to researchers hoping to partner with counterparts in China while retaining control over their own ideas and innovation. Very often, companies and researchers are reluctant to share their technologies under development with Chinese partners without years of collaboration and trust. As we will see below, more rigour is being enforced in the system under President Xi's new administration, though not necessarily exactly in the way expected in Washington and other Western capitals.

[55] SIPO. (November 2011). Patent Statistics Briefing. See: http://www.sipo.gov.cn/ghfzs/zltjjb/201310/P020131025653455401817.pdf

[56] Richard Van Noorden, *Nature.*

[57] Thomson Reuters IP and Science, *China's IQ (Innovation Quotient): Trends in Patenting and Globalization of Chinese Innovation*, Thomson Reuters, 2014, pp. 5, 13-14. Note also that "utility models patents" do not require inventions to be "novel" and last only ten years.

[58] Richard P. Suttmeier and Xiangkui Yao, "China's IP Transition: Rethinking Intellectual Property Rights in a Rising China", *National Bureau of Asian Research Special Report #29*, July 2011, p.13.

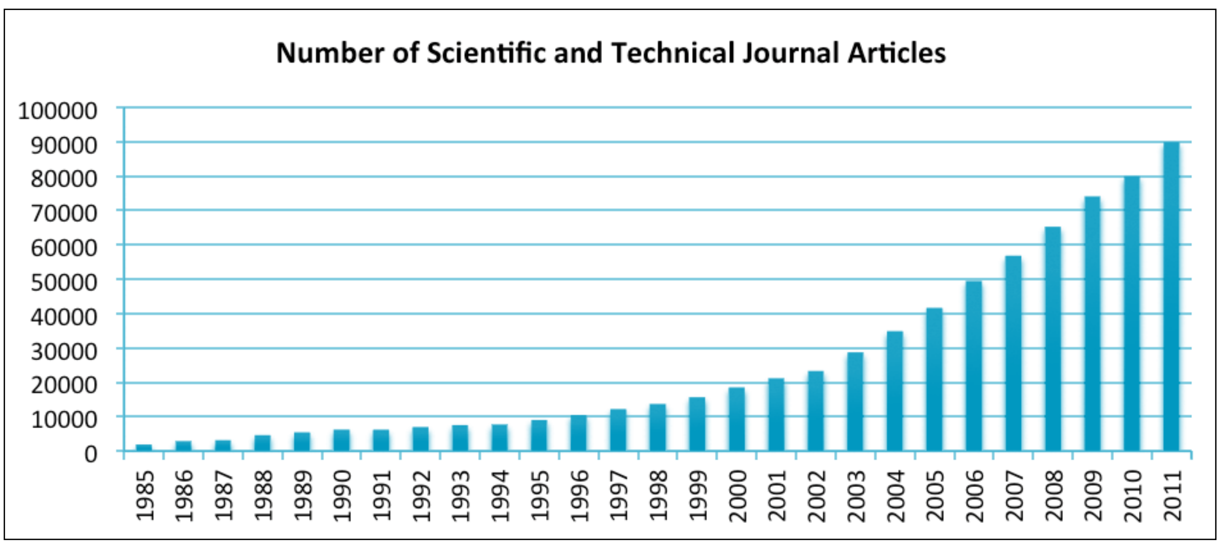
[59] Ibid, p. 19.

[60] Michael Martina, *"Geithner slams China's intellectual property policies"*, Reuters, September 23, 2011.

5. PUBLICATION OF SCIENTIFIC AND TECHNICAL JOURNAL ARTICLES[61]

According to the Institute of Scientific and Technical Information of China (ISTIC), between 2004 and September 2014, 1.37 million international papers were published by Chinese S&T personnel. The number of publications ranked No. 2 in the world and the rate of citations (10.37 million) ranked No. 4.[62] Figure 13 shows the trend of a dramatic growth in publications since the 2000s. The number of S&T publications climbed rapidly and kept pace with the increase of GERD.

Figure 13: China's scientific and technical journal articles;
Source: ISTIC



[61] Scientific and technical journal articles refers to the number of scientific and engineering articles published in the following fields: physics, biology, chemistry, mathematics, clinical medicine, biomedical research, engineering and technology, and earth and space sciences (definition from World Data Bank)

[62] ISTIC (2014), *Overall performance of Chinese scientific papers* (in Chinese: 中国科技论文整体表现, Pinyin: zhong guo ke ji lun wen zheng ti biao xian).Beijing: Institute of Scientific and Technical Information of China. pp.1,2. (hereinafter ISTIC 2014 report) See: http://www.igg.cas.cn/xwzx/kyjz/201409/W020140930590329622968.pdf

The National Science Foundation in the US combines European countries into one region for the purposes of publication stats, which places China third in numbers of papers published; it indicates that the number of Chinese papers published grew more than 15% annually from 2001 to 2011, and its global share of publications grew from 3% in 2001 to 11% in 2011.[63]

Among all the S&T publications, 33.8% are considered to be "distinguished papers" according to the Science Citation Index (SCI) statistics from ISTIC. Science, Nature and Cell are considered to be the top journals in the field of science and technology. ISTIC states that publications by Chinese researchers in these three journals were 226 in 2013, putting China in third place globally.[64]

As in any country, publications are an important factor on which Chinese academics are judged, and while quality has been improving, it is not yet at Western levels of excellence. China's National Innovation Index observes that since 2005, the number of citations of China's SCI papers has increased 3.9 times, the fastest growth of all countries except Luxemburg. Furthermore, China produced more than 10,000 "highly cited papers" during the period 2004-2013, accounting for 5.2% of the world's total and ranking fourth after the US (67,000), the UK (18,000) and Germany (14,000)[65]. However, the NSF reports that in 2012, China's share of highly cited articles was 37% less than expected given publication outputs.[66] In addition, plagiarism continues to be a concern, and is one of the systemic challenges that China's government has been attempting to address. Indeed, according to China's National Innovation Index 2013, "although China has had relatively high patent output efficiency and a world-leading number of publications compared to innovative countries in their corresponding historical stages, China still leaves much room for improvement in the quality of its patents and publications."[67] Furthermore, according to Cong Cao et al., due to the emphasis on number of publications required for promotion and recognition, scientists in China are now motivated to publish to increase their publication numbers and to receive grants rather than finding genuine solutions to societal problems.[68]

[63] National Centre for Science and Engineering Statistics, *Science and Engineering Indicators 2014*, Arlington: National Science Foundation, 2014, Chapter 5.

[64] ISTIC, 2014 pp 2, 3. See http://www.igg.cas.cn/xwzx/kyjz/201409/W020140930590329622968.pdf

[65] *National Innovation Index 2013*, p. 7. "Highly cited papers" refers to the top 1% of papers in their respective academic fields in order of citations.

[66] National Center for Science and Engineering Statistics, 2014.

[67] National Innovation Index, p. 58.

[68] Cong Cao et all (2013), p. 461.

6. GRADUATION RATES FROM UNIVERSITIES AND TECHNICAL COLLEGES

Arguably the most important input for an innovative society is the highly qualified personnel produced by the nation's post-secondary institutions. Investment in the training of graduates including scientists and engineers is reflected in graduation rates and changes year over year of higher education institutions.

In 1949, when the People's Republic of China was founded, there were only 21,000 graduates from colleges and universities. This number increased to 165,000 in 1978 when the national entrance examination was restored after the Cultural Revolution (1966-1976). In the 1980s and 1990s, the population of graduates gradually increased, with some fluctuations. Initiatives to stimulate the construction of top-level universities and the development of higher educational institutes were launched in 1995 ("211 Program") and in 1998 ("985 Program"). These two programs brought advanced education to a high level of national priority, with an accompanying focus on science education and awareness. The results of these investments started to become evident in 2000 with the rapid expansion of higher education institutions and a corresponding dramatic increase in the number of graduates.[69] By the end of 2010, China had 2,358 higher education institutions and 7,833 research institutions, altogether educating more than 22 million undergraduate students and 1.5 million post-graduates.[70]

These numbers demonstrate significant progress in both investments in, and results from, higher education. They also represent a remarkable, arguably unprecedented, lifting up of hundreds of millions of people out of poverty and into educated roles where they can contribute to the wealth and health of the nation.

At the same time, the rapid popularization of higher education has created concerns such as the debate of quality versus quantity.[72] In addition, nepotism, bribery and other forms of academic corruption have been considered by some to erode the system.[73] Along with these emerging issues, the government is facing growing challenges in matching the millions of graduates with the needs of development and the job market. In April 2010, the central government and the State Council issued the Outline of the National Medium-and Long-term Program for Talent Development (2010-2020).[74] The Outline puts an emphasis on training and increasing "talents" in science, technology and innovation.

[69] Erawatch. (June 2012). 211 Program. See: http://erawatch.jrc.ec.europa.eu/erawatch/opencms/information/country_pages/cn/supportmeasure/support_mig_0003

[70] European Commission. China- Overview of Structures of the Research System. See: http://erawatch.jrc.ec.europa.eu/erawatch/opencms/information/country_pages/cn/country?section=Overview&subsection=StrResearchSystem

[71] Data collected from the Annual Report of the National Bureau of Statistics of China, 2013.

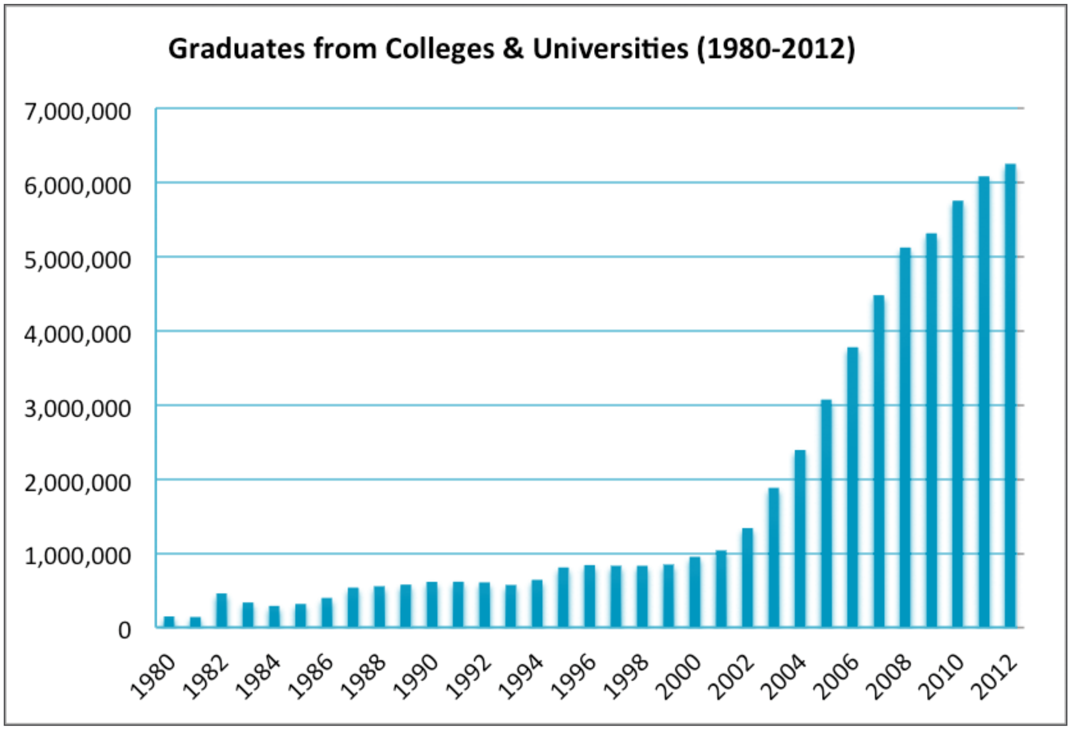
[72] Zhang Ming (June 22. 2008). Worries and solutions of expand of higher education. (In Chinese only: 高校扩张的隐忧与出路). Nandu news. See: http://epaper.oeeee.com/F/html/2008-06/22/content_497687.htm

[73] Schwaag-SergerSylvia, & BreidneMagnus. (Nov. 2007). China's Fifteen-Year Plan for Science and Technology: An Assessment. Asia Policy, pp.135-164.

[74] Original document in Chinese only (国家中长期人才发展规划纲要(2010－2020年)) See: http://www.gov.cn/jrzg/2010-06/06/content_1621777.htm

Figure 14: Graduates from Colleges and Universities (1980-2012):

Source: NBSC[71]



This brief overview of the dramatic increase over recent years in China's investments in R&D, patents, publications, and university and college graduates describes where the country stands today on some important variables of innovation. While China has made astounding leaps in innovation inputs, results across research disciplines and industry sectors have varied. In addition, systemic issues have arisen and the government has taken some action in past to address these. However, more significant measures were considered to be necessary by President Xi and the new State Council. The first of these was recently announced and is reviewed below.

IV. THE REFOCUSSING OF SCIENCE AND TECHNOLOGY
Under President Xi Jinping

On assuming office, President Xi Jinping began a number of policy reviews and campaigns to redirect the efforts of the country along new lines. His overall approach and philosophy has emphasized innovation driving economic development. Speaking on September 30, 2013 at a special meeting of the Political Bureau of the Central Committee of the CPC at Zhongguancun National Innovation Demonstration Zone, President Xi made a major speech on science, technology and innovation in which he stated, inter alia, that

" … scientific and technological innovation is a strategic support of improving social productivity and comprehensive national strength, so it must be placed at the core of national development…. The most urgent thing is to emancipate the mind, accelerate the speed of the reform of the science and technology system, and break all concepts and institutional obstacles that stand in the way of Innovation Driven Development…. It is imperative that we must improve the incentive mechanism, perfect the policy environment, stimulate enthusiasm and initiative of innovation…. eliminate the phenomenon of "islanding" of science and technology innovation, break the restriction of scientific and technological achievements' transfer and utilization, and improve the whole efficiency of the national innovation system."[75]

The speech described other changes that President Xi wanted to see regarding the development of talent, international collaboration, funding of R&D, and improving the relationship between government and the market. Clearly, he has strong views about the importance of STI to the fabric of China's economy and society.

Indeed, the decennial transfer to the next generation of leaders in China under President Xi is characterized not just by a new group of faces in government leadership roles. The backgrounds

[75] CCTV Network News Broadcast, Rough transcript by CCTV, September 30, 2013.

of the members of the Politburo themselves have shifted from a preponderance of engineers (17 in 2002-2007 and 14 in 2007-2012) to primarily political science (9) and economics (5), with few engineers (4) in 2012-17. President Xi has both a degree in chemical engineering and a doctorate in law from Qinghua University; Premier Li has a doctorate of economics from China's Harvard—Beijing University, widely known in China by its original name Peking University. It will be interesting to see how this shift in academic and professional backgrounds will impact the policies emerging over the next decade.

The most visible and far-reaching effort launched by President Xi is the anti-corruption campaign, which has impacted the scientific and academic communities through new rules constraining international travel, clamp-downs on plagiarism, more scrutiny of the use of research funds, and other measures which are expected to move China into the mainstream of international standards and norms of research and development. At least one senior S&T official has been caught up in the anti-corruption campaign. On December 22, 2014, the CPC Central Commission for Discipline Inspection announced that Shen Weichen, Party Secretary and Executive Vice President of the China Association of Science and Technology (CAST) had been expelled from the CPC and dismissed from public office, following a graft investigation that found that he took advantage of his post to accept "a huge amount of bribes" and had "received gifts and cash and committed adultery"; the financial proceeds from his actions were confiscated.[76]

1. REVIEW OF THE MEDIUM- TO LONG-TERM PLAN

In the area of science and technology policy, a mid-term review was undertaken of the 15 year MLP in order to reflect the major changes taking place in the scientific and economic landscapes in China and abroad, better understand China's innovation capacity, identify the main problems impeding S&T advancement, and make adjustments to the MLP accordingly. The timing of the review also served as a process by which President Xi could perform course corrections and adjustments based on his and the new State Council's view of the strengths and weaknesses of the innovation system in China.

According to Cong Cao et al., a 2012 National Conference on Science, Technology and Innovation, led by the CCPCC and State Council, was held to propose reforms to China's STI system with a view to further implementing the MLP. This conference in

[76] Xinhua, "Party chief of China's national science association expelled from CPC", Beijing, December 22, 2014.

turn led into a November 2012 directive of the 18th CCP National Congress which urged that action be taken to:

1. Clearly define missions of national R&D programs;
2. Separate entities of funding, research and performance evaluation in order to ensure checks and balances and accountability;
3. Apply different standards to the evaluation of different types of R&D activities; and
4. Make the rewards system more open and transparent

At the same time, a special Leading Group of State Scientific and Technological Reform and Innovation System Construction was appointed with representatives from 26 government agencies. It was headed by Liu Yandong of the CCPCC Politburo who was promoted to Vice Premier in early 2013. This new Leading Group was mandated to coordinate reform of the STI system and discuss and approve regulations. This group supplemented the LGSTE, with overlap in membership.[77] It is likely that it met more often than the LGSTE, for decisions on the reforms were to roll out fairly quickly. The Party leadership of this group, as well as Party involvement with the operational implementation of the reform reflects the strong political presence in steering the STI reform along with the corruption and other reform campaigns that are also being led by the Party.

Consultations took place across China, and in November 2013, foreign experts on China's S&T in key countries were invited to submit confidential written analyses and assessments of the MLP's success to date, China's innovation performance and capacity, difficulties in partnering with China, and recommendations for improvement. In January 2014, an International Evaluation Team of a dozen internationally renowned experts in China's S&T met in Beijing with senior members of China's S&T leadership for an in-person discussion of the MLP and China's innovation strategies more generally.[78] It found that the MLP itself was sound but that there were problems with implementation in areas such as governance, research integrity, tax policy, and R&D statistics measurements, while areas such as intellectual property and energy R&D have seen significant improvements. The foreign experts' advice was an important input to the Government of China as leaders designed the new changes in S&T policy, governance and programming.

Research Integrity

Issues of plagiarism and misuse of research funds have plagued China for decades and have been a serious barrier to its full participation in the international science community, as well as compromising the development of a sound system of innovation within China. While efforts have been underway since 1998 to try to address these issues, momentum has picked up under President Xi's government as an academic counterpart to the larger anti-corruption campaign. The latter has proven to be extremely popular with

[77] Cong Cao, et al, 2013, p.462.

[78] MOST. (2014). "Long-term Science and Technology Development Plan (2006-2020)" The mid-term evaluation of the International Advisory Council was held in Beijing. See: http://www.most.gov.cn/kjbgz/201402/t20140221_111930.htm

the general public of China, and support can also be expected for efforts to clamp down on cases of research duplicity.

Yang Wei, President of the National Natural Science Foundation has taken a leadership role, along with his colleagues at CAS and CAST, in establishing codes of ethics in the life sciences, and exposing and censuring scientists who plagiarize. Training in research ethics is being provided for students and faculty; however, Dr. Yang indicates that China is still grappling with putting in place panel reviewers, promotion committees, and prize nominators in the system that awards grants and titles—processes that have been in place for decades in Western research systems.[79]

China has become a very active member of the Global Research Council where the challenges of research integrity have had full discussion, leading to a Statement of Principles agreed to in 2013 by all 70 heads of research organisations from around the world. In May 2014, China (CAS and NSFC) co-hosted the annual Global Research Council meeting with Canada (NSERC) in Beijing.[80] As China accepts a stronger role in the international research community, it will be expected to address its research integrity challenges in a proactive manner, consistent with the policies and practices of other research councils and granting agencies.

Intellectual Property

With respect to the protection of intellectual property, President Xi has been concerned with moving his country toward international standards and modern regulatory regimes. He dispatched Premier Li Keqiang to Switzerland and Germany in March 2013 to meet with business leaders and indicate the government's commitment to IP protection.[81] At the same time, China needs to ensure that its huge investments in R&D and the increasing numbers of innovations developed by Chinese scientists and inventors are protected. SIPO Commissioner Tian Lipu has also been travelling the world to spread the word about China's commitment to a rigorous IP regime. On a visit to Ottawa in May 2013 to meet with Canadian government counterparts, he indicated that China is amending its copyright, trademark and patent laws to update and strengthen them. He emphasized that there has been a serious problem in past enforcement of patents granted, and that actions have recently been taken to enforce the laws when they are infringed, with 80 agencies across the government involved in protecting intellectual property.[82] In addition, new dedicated intellectual property courts have recently been established in Beijing, Guangzhou and Shanghai. Western companies will see this high level commitment as positive, but will be watching closely for evidence that it is being genuinely enforced in the course of doing real business in China. Western governments will be looking for proactive engagement by China in addressing international cyber-security infractions originating from within its jurisdiction.

[79] Yang Wei, "*Research Integrity in China*", Science 29, November 2013, pp. 1035-1039.

[80] See www.globalresearchcouncil.org/meetings

[81] Briefing by SIPO Commissioner Tian Lipu, May 31, 2013.

[82] Ibid.

Indigenous Technology

In 2014, the Government of China revealed more proactive steps towards favouring indigenous technology, as mandated in the MLP, in a new policy that will purge most foreign technology from banks, the military, SOEs, and key government agencies by 2020. This move also reflects a concern (according to reported sources familiar with the policy) about national security in addition to its indigenous innovation objectives.[83] In September 2014, the China Banking Regulatory Commission (CBRC) provided guidance to the banking sector to make its technology systems more secure. More details were released in December 2014, to take effect on December 26, to ensure that hardware and software in China's financial institutions would meet this goal, including inter alia: requirements for the CBRC to approve hardware and software used in the banking sector; IP must be controlled by a Chinese entity; a requirement that technology providers have an R&D facility and a customer service centre in China; and surveillance ports must be installed to enable CBRC access.[84] However, in April 2015, there was an uncharacteristic backtracking on this announcement. CBRC issued a letter indicating that the government was directing banks to "suspend implementation" of these rules while the regulations were reviewed. This suspension is temporary and could be lifted, or the initial rules could be clarified; there had been significant pressure from US-based firms such as Microsoft, IBM and Apple. The suspension could also relate to the planned September 2015 visit of President Xi to the US. But in the face of the President calling for China to become an "Internet power" with the new Cyberspace Administration of China playing a key role, the underlying policies are likely to be reinstated in most elements.[85]

China's strong attention to cyber-security is understandable in today's world. Presumably, they have observed the impact on sensitive research organisations in other countries when their systems are compromised, such as Canada's National Research Council, which identified serious hacking of its network as coming from a location in China. China itself has accused other countries of sponsoring surreptitious theft of technology and information. A pilot project in Siping was successful in replacing the Microsoft Windows system with a homegrown Chinese system called NeoKylin, and it is expected that this could lead to a wider replacement of Western IT systems with indigenous technology. President Xi has called for faster development of the IT industry so that Chinese organisations are not as likely to be the victims of hacking.[86]

This development will be of great concern to companies hoping to increase trade with China for their technology platforms. In 2011, faced with growing concerns expressed by foreign companies that wanted assured access to government equipment and technology orders without transferring IP and patents, China had committed to dropping some of

[83] Steven Yang, "China is Planning to Purge Foreign Technology and Replace with Homegrown Suppliers" in *Bloomberg News*, December 18, 2014.

[84] http://www.freshfields.com/en/global/Digital/China%E2%80%99s_new_cyber_security/?LangType=2057

[85] http://www.nytimes.com/2015/04/17/business/international/china-suspends-rules-on-tech-companies-serving-banks.html

[86] Ibid.

[87] Michael Martina, "*Geithner slams China's intellectual property policies*", Reuters, September 23, 2011.

its indigenous innovation rules.[87] This latest measure, however, would appear to go beyond to ban that technology from key sectors. While it is one thing to increase the R&D capacity in China so that their own researchers can go on to develop advanced homegrown technologies, as all countries do, it is another thing altogether to overtly replace large installations of IT and other infrastructure and software that comes from other countries. For many foreign companies, an R&D relationship was a route to sell their technology and infrastructure in the lucrative China market. It will be alarming to see their technology trade success stories up-ended, with their technology banished from the country; some foreign companies will not survive that change if they have put all their trade eggs in the Chinese basket.

Program Delivery

The STI governance and program delivery has been increasingly criticised, including by Chinese scientists. The fact that they have felt free to criticize the system openly suggests that their assessments were generally shared by others. In particular, the decision-making system managed by MOST has come under criticism for being determined by officials rather than by peer assessed merit, being wasteful, and not fostering the conditions for great science; it is felt that less state direction would result in a surge of scientific energy and more accountability.[88]

2. STATE COUNCIL POLICY DIRECTION

The State Council revealed its own priorities regarding S&T programs and funding processes on March 3, 2014 when it released its "Opinions on Improving and Strengthening the Management of Scientific Research Programs and Funds Financed by the Central Financial Budget".[89] Such "Opinions" documents from the State Council are akin to Cabinet decisions in Western governments. It provides the broad policy construction that will guide the governance changes described below. And like many Western Cabinet decisions, the substantive analysis and recommendations reflected in the State Council Opinions were undertaken in large part by officials of the responsible Ministry, in this case MOST, and were shaped by the special Leading Group of State Scientific and Technological Reform and Innovation System Construction mentioned above.

This document begins with a summary of key problems facing R&D programs and the management

[88] Will Hutton, *The Writing on the Wall: China and the West in the 21st Century*, London: Little, Brown 2007, Abacus 2008, pp. 157,158. The researchers in question are Yi Rao, co-Director of the Shanghai Institute for Advanced Studies and Bai Lu, advisor to MOST and senior investigator at the National Institutes of Health.

[89] The original Chinese of the State Council's Opinions document is available at http://www.gov.cn/zhengce/content/2014-03/12/content_8711.htm

of funding for such programs, specifically: duplicative and decentralized arrangement of programs; a lack of full transparency in management; and efficiency in using funds to be improved.
Seven policy directions were provided with detailed instruction under each:

1. Strengthen the coordination and allocation of funds/resources (for R&D projects)
2. Manage the programs in separate categories
3. Improve the management process of R&D programs
4. Improve the management of funds
5. Enhance the regulation of research projects and funds
6. Establish and improve the basic system (information disclosure and technical reports)
7. Enhance the responsibility of relevant authorities for the implementation of the policies

A detailed summary of the highlights of the Opinions document can be found at Appendix 4 of this paper. A repeated theme of the sub-points of these directions is the need for effective project selection, primarily by peer review based on transparent and competitive selection: shorten project review and selection cycles to no more than 120 days; implement a rotation system of experts in project selection and assessment, including foreign experts and representatives of industry (the latter for market-oriented projects), with the proportion of front line scientists being approximately 75%; and improve S&T evaluation and reward systems.[90] This has been a key focus of the Government of China in recent years as they have searched for tools to improve the quality of the research and outputs from the innovation system. They have been eager to learn from other countries' systems on project selection and evaluation processes in particular.

In addition, the State Council Opinions calls for S&T programs with unclear positioning, duplication, or ineffective performance to be eliminated, integrated with another, or transformed in other ways. Basic and frontier research projects are to be targeted on original innovation. Major projects should reflect national objectives, and should receive concentrated or pooled resources in order to concentrate funding on significant issues and key breakthroughs. Researchers will be further supported through an assessment system that will "encourage exploration and tolerate failure", and financial incentive systems will reflect their position responsibilities and work performance. In addition, researchers' mobility is to be strengthened, including for exchanges with companies. The government also intends to create a comprehensive national S&T management information system accessible by the general public.[91]

[90] European Commission, EURAXESS, http://ec.europa.eu/euraxess/index.cfm/links/singleNews/46477

[91] Ibid.

3. GOVERNANCE AND PROGRAM CHANGES

On October 20, 2014, the Government of China announced an impending major shake-up of science funding, with MOST giving control over its research spending to "independent institutes".[92] Senior officials[93] in MOST and the Ministry of Finance were made available to be interviewed about the broad new directions being taken by the government but many details of the reforms, to be implemented over 3 to 5 years, have not yet been revealed. Initial indications are that the changes are intended to have a significant impact on China's R&D efforts.

Titled "The Plan on Deepening the Financial Management and Reform of the Central Government's Science and Technology (Special Projects, Funds, etc.)",[94] the Plan's purpose is to address current problems in the management of S&T projects, particularly the dynamic of too many organisations managing the same issue, lack of coordination and communication among departments and agencies, fragmentation of resources, duplication of applications (same proposals for different funds), and researchers expending excessive energy seeking project funding. In addition, the S&T financial system was considered to be too decentralized, not transparent, too duplicative, and inefficient in the use of resources.[95] The new approach will comply with the following five principles:

1. Change the government's function in managing S&T issues
2. Focus on the important, strategic tasks
3. Promote and deepen the integration of development in S&T and economics
4. Clarify the relationship between government and the market; and
5. Insist on the principle of open, transparent and social supervision

According to MOST documents, the government will no longer be both an 'athlete' and a 'referee'. There will be an "open and unified platform of management" with a "strategic consulting and comprehensive advisory committee" led by MOST for coordination and decision-making on policy, priorities and planning; the committee, known as the "Ministerial Joint Meeting System", will report directly to the State Council and will be supported by MoF and NDRC, with these agencies coordinating closely with MOST at the working level.[96] The Chair of the Committee is the Minister of Science and Technology with direct involvement and support provided by the

[92] *People's Daily*. October 21, 2014. Available at: http://www.most.gov.cn/ztzl/shzyczkjjhglgg/dtxw/rmrb/201410/t20141022_116259.htm Details of the reform are available at: http://www.most.gov.cn/ztzl/shzyczkjjhglgg/

[93] Zhang Xiaoyuan, Director-General, Department of Facilities and Financial Support, MOST; and Zhao Lu, Director, Department of Education, Ministry of Finance, *People's Daily*, Ibid.
Zhang Xiaoyuan See: http://www.most.cn/eng/organization/Departments/200810/t20081030_64676.htm
Zhao Lu info see: http://jkw.mof.gov.cn/zhengwuxinxi/guanyuwomen/lingdaozhici/201004/t20100426_289101.html

[94] In Chinese: 《关于深化中央财政科技计划（专项、基金等）管理改革的方案》Pinyin: guan yu shen hua zhong yang cai Zheng ke ji ji hua (zhuan xiang, ji jin deng) guan li gai ge de fang an. The original Chinese uses "etc" suggesting that this overall plan covers these two things along with others.

[95] From MOST, see: http://www.most.gov.cn/ztzl/shzyczkjjhglgg/dtxw/kjrb/201410/t20141022_116266.htm

Secretary General[97] of the CPC assigned to MOST. This is important because it shows the involvement and control being exercised by the Party in these governance changes, just as the CPC is managing the anti-corruption campaign processes and investigations.

Third party institutes will manage the selection process and be the funders and oversight managers of competed S&T projects. NSFC, with its highly regarded peer review system, is a model of such an organisation, and others will be created. Each institute is to have good internal and external monitoring systems (e.g. a sophisticated structure of corporate governance and articles) to regulate the organisation's behaviour, and the State Council has stipulated that no subordinate unit of any department should attempt to become one of these organisations by changing its name only. However, it is anticipated that current qualified public institutions (e.g. program offices of MOST (reconfigured) and arms-length institutes of the MOST portfolio and other ministries) can be transformed into standardized, professional program management institutions. These professional institutions will handle the applications of projects to the suite of programs through the unified national S&T information system which will cover all programs both local and national and will be accessible by the general public. They will also organize the evaluation, selection, process management and closing of the projects, and will ensure that the projects' goals have been met.[98]

The Plan involves major changes in the financial management of China's S&T programs, including these elements:

- government will no longer manage S&T projects or decisions about project funding directly;
- an open, unified platform managed by third-party organizations will be established to manage the decision-making process to select the projects;
- a strategic consulting and comprehensive advisory committee will be established by MOST; and
- the future focus will be on China's national strategic development projects.[99]

The new Plan will have five major categories, and each of the previous programs will be integrated into one or more of these categories, with financial resources being more concentrated.

- Natural Science Foundation of China for basic research
- National S&T major projects identified in the MLP (eg., aerospace, ICT)
- The national "key" research and development plan for international cooperation and areas key to social and economic development
- Special fund for enterprises for technology innovation
- Special projects for infrastructure and talents

[96] From MOST, see: http://www.most.gov.cn/ztzl/shzyczkjjhglgg/dtxw/kjrb/201410/t20141022_116271.htm

[97] Within the Ministry itself there is also an official with the title Secretary General of the Ministry's bureaucracy

[98] Wu Bing, "973 and 863 programs will be integrated into the five categories of S&T plan", *Southern Metropolis Daily*, January 13, 2015.

[99] Content of the new policy is synthesized from MOST's analysis on the policy 'The Plan on Deepening the Financial Management and Reform of the Central Government's Science and Technology (Special Projects, Funds, etc.) ': http://www.most.gov.cn/ztzl/shzyczkjjhglgg/dtxw/kjrb/201410/t20141022_116271.htm (Oct. 21, 2014) and: http://www.most.gov.cn/ztzl/shzyczkjjhglgg/dtxw/kjrb/201410/t20141022_116266.htm (Oct. 22, 2014)

In this last category, the Hundred Talent and Thousand Talent programs to attract top researchers from abroad are now being assessed to determine if they are meeting their objectives, given their high cost—whether they are the best use of scarce resources to bring Western scientists to China for temporary stays, or if there is a better alternative for investment in Chinese innovation. In addition, and certainly more problematic in the context of the overall anti-corruption campaign, the Talents suite of programs have come under recent criticism, due to allegations that the funding provided to attract foreign scientists was diverted away from the designated research area for unknown purposes. A number of recent cases have been profiled in the media suggesting that the funding never appears in the lab where the scientist is to work or that a substantial amount was diverted. Furthermore, some Western scientists are allegedly not actually conducting the promised research in China as they have full time positions elsewhere; to give up their tenured position for a few years in China is a difficult prospect for many.[100] Clearly, the programs are being assessed to determine how they will be transposed to the new program configuration, and what policy, program design and operational changes will be necessary to achieve this goal. While the programs have indeed brought in foreign talent at a time when China needed it, the new emphasis on homegrown innovation may put a renewed emphasis on developing China's domestic talent. As Yu Wei and Zhaojun Sun of Peking University suggest, "We need to provide returning overseas talents and local talents with a platform to realize their common and harmonious development, and thus enable them to become an important force in leading S&T innovation and economic development."[101]

The five program categories described above, or functional types as they are also known, will be integrated to create the unified platform referred to in the State Council Opinions. At the time of the National People's Congress on March 11, 2015, Minister of Science and Technology Wan Gang reported at a press conference that the first 47 of the close to 100 programs affected had already been integrated.[102] Professor Lan Xue, Dean of the School of Public Policy and Management at Tsinghua University, has commented on the recently announced measures, indicating that the need to improve coordination and reduce fragmentation among government agencies has led to the consolidation of the national R&D programs into the five functional types.[103] However, in looking at the next steps, it is not immediately evident how fragmentation will be improved by having the programs moved out of ministries and agencies to be managed by more non-government organisations. Surely, they will be more numerous, more independent of government, and consequently more challenging to coordinate. Minister Wan provided some explanation in this regard at his March 11 press conference, when he indicated that there are various models for such professional institutions around the world; some are independent from government and others are not. He stated that

[100] Mara Hvistendal, "China's Programme for recruiting foreign scientists comes under scrutiny", *South China Morning Post*, November 3, 2014.

[101] Yu Wei and Zhaojun Sun, "China: Building an innovation talent program system and facing global competition in a knowledge economy", *The Academic Executive Brief*. Available at http://academicexecutives.elsevier.com/sites/default/files/AEB_2.1_Wei_Sun.pdf

[102] Wan Gang at http://www.china.com.cn/zhibo/zhuanti/2015lianghui/2015-03/11/content_34996059.htm and http://news.xinhuanet.com/english/china/2015-01/15/c_133922256.htm

for China, at this stage, it will be practical to start with government-affiliated institutions (which can be transformed into professional institutions), and in the future "we will gradually reform these institutions to make them more market oriented." He also indicated that a key role for the government would be mid-term and final evaluations and supervision.[104]

The lack of coordination across the government must be addressed in both high level policy as well as operational and information exchange. We have seen two new organisations created to drive the reforms: the special Party-led Leading Group of State Scientific and Technological Reform and Innovation System Construction and the MOST-led "Ministerial Joint Meeting System" appointed to implement the reforms. The three-year implementation period (described below) is an aggressive timeframe, but one element of the decision-making will need to be the longer term, ongoing platform for policy decisions as well as operational coordination. This is where Canada could provide models for consideration: Cabinet committees for high level, ongoing policy direction, and several shadow committees at the Deputy Minister and Assistant Deputy Minister levels for operational coordination and information exchange. Granted, Canada's smaller size of government makes such fora easier to put in place and get things done. However, it is the very size and complexity of China's S&T governance system that requires such ongoing mechanisms to be implemented. Once the transition is well underway and moving toward completion, a re-mandating of the MOST-led committee, with the appropriate membership, would be a good place to start. A shadow committee at a lower operational level would then be mandated to manage the coordination on a week by week basis. Such an innovation in the machinery of government would go some distance to communicate to the research community in China that a unified platform has indeed been created. In addition, it will be particularly important given that arms-length institutes will be managing the programs; there will need to be an effective mechanism to keep them engaged and coordinated collectively within the unified platform.

For the new assignment of financial resources under the new program configuration, the Ministry of Finance will plan and allocate the funding of the S&T programs, the current level of funding now set at $39.5B USD, ending the fragmented nature of funding for S&T programs. Shi Zhengwen, Director of the Centre for Research in Fiscal and Tax Law of CUPL, said that: "Previously each ministry was working separately. This caused duplication and fragmentation in the use of funds. Under the new joint system, MOF will allocate and plan as a whole, focussing funding in areas where the market is not able to allocate resources effectively (frontier science, public welfare, and important "key" technologies). This is hoped to improve the coordination in projects' approval, optimize the allocation, and promote efficiency."[105] However, according to MOST officials, the funding of each of the five will not be determined by simply adding up the budgets of each of the programs or funds assigned to it. Rather, programs could be

[103] Lan Xue, "Promoting Innovation-Driven Development in China and International S&T Collaboration", conference panel presentation, December 5, 2014, pp 18-20. Available at http://www.bm.ust.hk/~mgmt/2014MOR/Panel1/Panel1_LanXue.pdf
[104] Wan Gang press conference, March 11, 2015.

reorganised or recut, with their budgets broken up and reassigned in a new budget. In other words, the budgets of current programs will be completely fungible within the new program configuration. The Ministry of Finance, in consultation with NRDC and MOST, will determine what budget is appropriate for the configuration of programs once the new program structure has been determined. In the meantime, it is business as usual, with current program offices accepting and reviewing project proposals, as in the past, until the new program configuration becomes formalized.

It is interesting to note that the governance and program changes announced in China are still in the early stages of planning. The broad direction and overall objectives are now known, but the details of the new structure, which agencies will be responsible, and what budget levels will be assigned are subject to inter-ministerial consultation, review of options, and consideration of Ministers, with recommendations to State Council. This is not at all the process that one would see in countries such as Canada where machinery of government decisions are the prerogative of the Prime Minister, and options for departmental reorganisations are quietly considered internally in the Privy Council Office, sometimes without ministerial involvement, and announcements are made when decisions have been taken at a fairly high level of detail. Departments are then mandated to implement what has been decided. China's approach is more iterative, with broad directions identified but details to be discussed, considered and adjusted over a three-year timeframe. It is interesting that in governance matters, a Communist government can be more open and flexible in governance matters than a democratic government.

A highlight of the reform will be the creation of the "National Key R&D Plan" within which the following programs will be first disassembled and then reorganized, under a new name or names yet to be determined. These are programs that require a competition for the selection of projects. It is anticipated that, following consultation on program structures and responsibilities, there will be a completely new program (and perhaps sub-program) configuration.

- 973, 863, Support Program, the International S&T Cooperation Program (ISTCP) managed by MOST
- Funds for industrial R&D managed by NDRC & MIIT
- Special projects on scientific research regarding public welfare managed by relevant department

Not all programs are listed here; the list includes some of the most important S&T programs. However, all S&T programs are expected to be affected to some degree. According to MOST officials, the International S&T Cooperation Program will be enhanced in a new form, and its program capacity (perhaps under a

[105] Wu Bing, January 13, 2015. The $39.6B is in the context of China-wide government expenditures of $82B USD (which includes provincial and local). Therefore, major reform of this funding is significant in the nation-wide context.

new name or configuration) will continue to be a key vehicle for collaboration on R&D projects with other countries.

The changes will roll out over the following years:
2014 – Launch the construction of the national platform in S&T management; integrate and optimize the qualified S&T plans (special projects, funds etc.); launch pilot projects in key areas;

2015 to 2016 – Complete the construction of the open and unified platform; complete the integration and optimization of projects and funds; realize the coordination of budget for projects and funds;

2017 – The five new categories of S&T plans will run regularly through the transition; current channels for projects and funds will no longer exist; there will be "continuous reform in practice".[106]
Throughout the transition process, there are to be updates on the progress of the reforms on the MOST website.[107]

Ministry of Science and Technology (MOST)

The overall governance structure described earlier in this paper continues with most modifications to functional responsibilities falling in MOST and CAS. MOST will have an enhanced and more explicit mandate for coordination and communications across other ministries and agencies, through the joint inter-ministerial committee that it will Chair and support to the committee from the Ministry. Ministry of Finance, NDRC, MOA, MIIT, SIPO and other sectoral ministries that currently have their own programs will participate on the committee which will review, plan, and determine the detailed establishment of S&T program delivery. At the same time, MOST and the other sectoral ministries will lose their direct responsibilities for selection and oversight of projects—a function which gave Ministry officials important levers to determine the priority activities in the research community and agility with international partners in timely selection of joint projects. The new process will ensure a more internationally recognized arms-length and peer review process for the selection of projects. The new structure is expected to take several years to be fully implemented and many of the organisation and process decisions have not yet been made, though there has been assurance that already-approved projects will not be affected. In the meantime, some of the program offices are already going through initial changes, while at the same time they are continuing to accept project applications.[108]

The third party institutes that will deliver the new suite of programs have not yet been identified or created. The only specific model explicitly identified is the NSFC with its widely recognized peer review system. According to MOST officials, these new arms-length program delivery institutions could be one or more of the numerous organisations currently established in the MOST portfolio of agencies, either on their own or in a merger with others, and in addition new ones can be created. As indicated above,

[106] The timeframe is described along with other details of the plan in MOST's October 22, 2014 analysis available at http://www.most.gov.cn/ztzl/shzyczkjjhglgg/dtxw/kjrb/201410/t20141022_116266.htm

[107] Wan Gang press conference, March 11, 2015.

Minister Wan has described a two-stage process whereby institutions currently associated with the government will be given the lead, but in the longer term they could be reformed to become more market-oriented. A list of the most important of these agencies is included in this paper at Appendix 5.

MOST's most important S&T programs have been the 863 National High-tech R&D Program and the 973 National Basic Research Program.[109] These two programs have been key to China's S&T development since they were created in March 1986 and March 1997, respectively. The announcement of the changes noted that wastefulness and fragmented management have led to overlaps and the inefficient use of funds; it also cited the need for a unified platform for distributing grants.[110] Minister of S&T Wan Gang told China Radio that he welcomed the changes, saying that it is intended to "get rid of the shackles on technological innovation."[111]

Chinese Academy of Sciences (CAS)

CAS is undergoing significant changes as well. At a briefing on May 22, 2013 with senior officials from across the Government of Canada, the President of CAS Bai Chunli described changes that had already begun at CAS in response to the government's call for reform. He addressed in particular the need to enhance co-innovation, cooperation and efficiency through streamlining, and enhancing multi-disciplinarity and the linkages between science and technology. He indicated that they were in the process of reducing administrative overlap, reducing barriers to collaboration, while increasing integration and unification of the institutes. In addition, the headquarters' fragmented management structure was being reorganized and more authority was being delegated to the institutes.[112]

More recently, a major reform of CAS institutes was announced in September 2014 in advance of the government's broader S&T governance changes. CAS President Bai has said that it is "the biggest reform in the academy's history". According to Dr. Bai, one of the problems identified at CAS is the underperformance of scientists who have low salaries that they must supplement by applying for multiple grants, thereby fragmenting their research. In addition, there has been a reluctance to collaborate with others, as co-authorship dilutes their achievements in the eyes of grant committees. This results in duplication of research among researchers who often have never met. In addition, Dr. Bai has asserted in an interview with Nature that CAS scientists have had little interest in discussing applications with industry.[113] To obviate these problems and lost opportunities, Dr. Bai has grouped research into four categories:

1. Centres of excellence in basic science (e.g. brain science);

[108] Interviews with several MOST officials, November 2014 through January 2015.
[109] Christina Larson, *Overhaul of Chinese science spending looms* in AAAS sciencemag.org, October 2014 p1. See http://news.sciencemag.org/asiapacific/2014/10/overhaul-chinese-science-spending-looms
[110] David Cyranoski, *Fundamental overhaul of China's competitive funding* Oct 23, 2014 in *Nature News Blog*
See …….
[111] Larson, p.2. http://www.most.gov.cn/xinwzx/mtjj/ztjj/201410/t20141021_116254.htm
[112] Bai Chunli, "China's S&T System and CAS Structure", Presentation at the Department of Foreign Affairs, Trade and Development, May 22, 2013, pp 17,18.

2. Disciplines with as yet underdeveloped commercial potential (e.g. marine information technology);
3. Collaborations of large-scale facilities (e.g. linking Shanghai's synchrotron and protein-science centre to carry out high precision protein studies); and
4. Initiatives to assist local development and sustainability (e.g. preparing for natural disasters such as landslides).[114]

Promising CAS scientists are being identified to work together under each category, with higher salaries and with grants for only 30% of their income rather than 70%.

However, one unnamed Chinese university professor interviewed by Nature suggested that these changes will not address the root problem at CAS, including hiring too many young scientists who go through little or no review and are given tenure without proving themselves. Dr. Bai countered that the opportunities offered will "encourage underperformers to do better". He indicated that he had avoided a US-style system in which underperformers can be fired. He refers to his approach as "a reform with Chinese characteristics".[115]

It should be noted that CAS' Institute for Policy and Management has played an increasingly important role in the analysis of issues and challenges in China's S&T system, providing policy advice that was drawn upon in developing the government's new governance changes. In addition, CASIPM has advised on issues in the operation of CAS itself, which has led to the reforms of the organisation that are now underway.

National Natural Science Foundations of China (NSFC)

According to Xinhua, the state-run newswire, "China will reform state research fund management, delegating power to independent institutes in a bid to curb academic corruption and sharpen innovation… The government will no longer be in direct charge of research projects." The People's Daily reported that the Communist Party's Central Committee and the State Council have approved the plan.[116]

In the context of these governance changes, Zhao Lu, Director of the Education, Science and Culture Department of the Ministry of Finance, told Xinhua in October 2014 that the NSFC could be a model for a new agency to manage R&D spending. In the context of China's S&T system, NSFC has long had a positive reputation for transparency and peer review of projects.[117] Whether NSFC itself is used as a designated institute, or is used as the foundation of a larger institute that will be the product of a merger with other organisations, is yet to be seen. There is no doubt China will want to build on this respected agency, which has strong linkages and partnerships with its counterparts in other countries, such as the Natural Sciences and Engineering Research Council in Canada.

[113] David Cyranoski, *Chinese science gets mass transformation* See http://www.nature.com/news/chinese-science-gets-mass-transformation-1.15984
[114] Ibid pp. 2-3.
[115] Ibid p. 3.
[116] Larson, p.2.

4. ENTREPRENEURSHIP AND INNOVATION

Changes to incent innovation are also being introduced in the context of entrepreneurship. On March 11, 2015, the State Council issued another important Opinions document linking entrepreneurship and innovation as the "twin engines" of economic development, while also positioning increased supplies of public goods and services as an important factor in development.[118] The State Council committed to provide a better environment for entrepreneurship and innovation by lowering barriers, strengthening public services, and encouraging scientists, engineers and university students to start new businesses. Equity-based online crowd funding will be piloted, and financial institutions will be encouraged to provide financing to small businesses. Already, China is expanding its base in entrepreneurship through its 115 university science parks and 1,600 technology business incubators, which provide services such as office space and management training to start-up technology companies. Together, they are incubating more than 80,000 enterprises and employing 1.7 million people. The State Council wants these numbers to ramp up considerably.[119]

While the Opinions document laid out in broad terms the new priority being given to entrepreneurship, on March 23, 2015 Premier Li Keqiang made public another document which had been jointly prepared by the State Council and the CPC Central Committee, and which described in more detail the specific measures that would be taken to incent behaviour and reduce barriers.[120] There is to be more protection of intellectual property and more market competition. SMEs are to be encouraged with innovative companies enjoying favourable tax measures. National innovation programs are to consult companies to determine their needs, while continuing to take "strategic needs" into account. Research organisations will move inventions to commercialisation, and will be allowed to retain profits in order to award scientists and fund future research projects.

There will be a relaxation of rules applying to foreigners with technological talent who will more easily be able to apply for permanent residence permits (for example, the age limit could be lifted and they may be allowed to enjoy the same treatment as Chinese nationals when founding S&T enterprises), and the government will consider a new system for allowing some foreigners to apply for Chinese citizenship. All of this will be in the context of projects chosen via peer review to assess research quality and originality. Chinese researchers will be encouraged to participate in international S&T projects, as well as initiating such projects on basic and global topics in order to access the wisdom of leading scientists in other countries.

[117] Larson, p.2.

[118] The Chinese of the State Council's Opinions document "Opinions on developing the space of mass innovation and promoting the public innovation and entrepreneurship"; In Chinese: 国务院办公厅关于发展众创空间推进大众创新创业的指导意见 can be found at http://www.gov.cn/zhengce/content/2015-03/11/content_9519.htm

[119] English highlights of the Opinions document are reflected in this Xinhua article: http://news.xinhuanet.com/english/2015-03/11/c_134059020.htm

[120] The CPC Central Committee & State Council document "Opinions on deepening the reform of institutional mechanisms to accelerate the implementation of the strategy of innovation-drive growth" and in Chinese: 中共中央 国务院关于深化体制机制改革加快实施创新驱动发展战略的若干意见 is available at: http://www.gov.cn/xinwen/2015-03/23/content_2837629.htm

There will be a legal and institutional framework developed by 2020 that will allow free movement of talent, capital, technology and knowledge in order to encourage coordinated innovation and enhanced efficiency.[121]

All of these measures will send signals to the system to encourage innovation and entrepreneurship, but the government will also need to ensure that very specific incentives are in place, and assess progress closely and recalibrate if necessary. Nevertheless, the capacity of their system, even as huge and complex as China's, and their focus on meeting targets and objectives, suggests that they will meet most if not all of their objectives. The question for Canada and other nations is the extent to which these measures will open up new partnership opportunities for their own innovation and entrepreneurship hubs to partner with those in China.

5. NEW INDEPENDENT THINK TANKS

Another area of change recently announced by President Xi is that China would be developing world-class think tanks to offer independent policy advice. On October 27, 2014, he chaired a meeting of the Leading Group for Overall Reform that reviewed a document on strengthening the creation of new "think tanks with Chinese characteristics". Specifically, he indicated at the meeting the importance of intellectual resources for the development of the nation, but that at the present time, China lacks think tanks with great influence and international reputation: "Building a new type of think tank with Chinese characteristics is an important and pressing mission. It should be targeted on promoting scientific and democratic decision making, promoting modernization of the country's governing system and ability, as well as strengthening China's soft power."[122]

However, President Xi also indicated that the think tanks would be led by the Communist Party of China (CPC) and "adhere to correct direction", and should abide by scientific spirit and encourage researchers to make explorations and study. Most central agencies and ministries have internal policy branches (such as Development Research Centre (DRC) in the State Council Office and CASTED in MOST) that operate as internal think tanks, undertaking research and providing recommendations and policy advice, as do agencies such as CAS, the People's Liberation Army, and enterprises. The President indicated that the ministries' internal policy groups should be developed in a coordinated way into a think tank system with clear definitions, forms and appropriate scales; that a number of them should have an international reputation and influence; and that some professional think tanks should be built.[123]

[121] The English Xinhua report of this document can be seen at: http://news.xinhuanet.com/english/2015-03/23/c_134090877.htm

[122] "Xi calls for new type of think tanks", *icrosschina*, October 27, 2014. See http://app.icrosschina.com/?app=article&controller=article%action=show&contenttid+4824 Others attending this meeting were Li Keqiang and Liu Yunshan, who are members of the Standing Committee of the Politburo, and deputy heads of the group.

[123] Ibid.

Following President Xi's October 2014 speech, the State Council issued the "Opinions on Strengthening the Construction of New Think Tanks with Chinese characteristics" document on January 20, 2015.[124] The four kinds of think tanks foreseen are:

i. Military or political think tanks - Within the party, government or military departments, provide decision-making services for the leadership. Examples are: the Development Research Center of the State Council Office, and various levels of Party Schools;
ii. Chinese Academy of Social Sciences - This is the type of think tank with Chinese Characteristics. These think tanks are non-governmental organizations that have important influences in policy-making. Their source of funds is grants or subsidies (from government). The major form of policy consultation is commissioned projects;

iii. Think tanks in higher educational institutes - Organizations that are affiliated with universities and doing research on policy and decision-making. These think tanks are created by the universities, in some cases and/or with the assistance of other institutes. Their advantage is the collection of high-level academic experts and the leading stature that they hold in the discipline; and

iv. Private think tanks - Primarily funded by private organizations – they are policy research organizations that reflect the voice of the public. Most of them are created by businesses, NGOs and other private organizations. An example is the First Century Education Research Institute.[125]

Knowing the roles and attributes of Western think tanks, however, one wonders if China is really ready for the kind of public, independent policy advice that the best Western think tanks provide. Indeed, Western governments often find such advice difficult to receive and implement. It seems highly unlikely that President Xi would permit significant public criticism of the government's S&T policy directions by "independent" think tanks. Perhaps his reference to "think tanks with Chinese characteristics" reflects the degree to which they would be circumscribed. However, given President Xi's clear public pronouncements about his intention to develop independent think tanks, the Western policy and governmental community will be watching closely to gauge their true independence.

This initiative is aided in part by a review undertaken by officials of the Development Research Centre (DRC) of the State Council of China who travelled internationally in July 2014 to assess the practice of think tanks, independent policy research organisations and government affiliated research groups in other countries, to determine whether China might spin off or develop its own think tanks to become independent sources of advice. The group also wanted to assess the interaction between government and the public about public affairs and policy effectiveness. Subjects covered included organisation, mandate, how research was conducted, governance, partnerships, and fund management of key research areas, as well as the role of non-partisan and independent think tanks on bringing about reform and promoting democratic participation of citizens in addressing policy challenges. At that time it was indicated that some of

[124] Original State Council document available in Chinese at http://www.gov.cn/xinwen/2015-01/20/content_2807126.htm
[125] CPC News, "Why Xi Jinpin put emphasis on the construction of New Thank Tanks?" Oct.29, 2014.
Available at: http://theory.people.com.cn/n/2014/1029/c148980-25928251.html

[126] Personal notes from briefing meeting with the State Council Office delegation, July 9, 2014. In fact, the DRC is itself a think tank of 30 years' history within the State Council Office.

the ministries which currently house internal policy think tanks (CASTED in MOST is one of these, though CASTED was not directly named) might have all or part of those groups spun out to become independent think tanks; others would be created in universities.[126] If ministry policy groups such as CASTED were to become a think tank, at least part of the organisation would need to remain within MOST to undertake the ongoing analysis and advice that a government department of any country needs to have internally.

Clearly, President Xi has moved to put his own stamp on the development of S&T, with a view to making China one of the world's most innovative nations. Much is new in the changes announced in recent months. However, there remains much that is not yet determined, particularly with regard to program changes, which is where researchers and companies require certainty and clarity. In Western countries, machinery of government changes are normally refined to a high degree of detail before being announced. In China, the practice more closely resembles "continuous reform in practice", with adjustments and revisions being made as more experience and input is received. This is likely to result in a higher quality of reorganisation overall, but will most certainly involve a high degree of uncertainty and delays in research agendas in the interim.

[126] Personal notes from briefing meeting with the State Council Office delegation, July 9, 2014. In fact, the DRC is itself a think tank of 30 years' history within the State Council Office.

V. CONSIDERATIONS FOR CANADIAN GOVERNMENTS, BUSINESSES AND RESEARCHERS

Without a doubt, the Government of China is seized of the challenges that the nation has had with elements of the STI system, and how the components work together. President Xi has mandated reviews and changes across the system involving many organisations and virtually all areas of STI policy. At the same time, major changes of governance take many years to shake out, and changes in policy and implementation can take some time to be seen in the real world of research. It will take consistent messaging and coordinated implementation to ensure that the value of the new governance and new policies is realized.

Canadian governments, businesses and researchers would do well to become familiar with the changes as the details are made clearer over the coming months. Their Chinese counterparts will be dealing with these governance and program changes during this period, assessing how the new directives will affect their own roles and power levers in the China's innovation system. While the Government of Canada has focussed on China as a key target market, provincial governments have themselves launched significant initiatives to place their companies and researchers in a position to benefit from the emerging opportunities in China. As the new STI landscape in China emerges, the provinces and Canadian municipalities should be ready to engage with the new programs and partners. One of the key Canadian government initiatives involving China is the International S&T Partnerships Program (ISTPP). Since it was established in 2005, the project selection process has been managed by International S&T Partnerships Canada, an arms-length agency; it was tasked with deepening collaboration with China, India, and Brazil in particular, including managing the Canadian peer review process for selecting joint projects under the jointly funded bilateral programs. China would have preferred to have a line department or agency manage the project selection, as MOST did for decades in China.[127] But now we see that this project selection process in China is to be delegated to independent research institutes—the form of these institutes is still to be determined. At the same time, Canada is poised to bring the selection process back into direct government control in order to provide more oversight of the allocation of funds, improve accountability, and increase alignment with other government programs targeted at SMEs. Such are the waves that governance changes tend to go through—in this case, with Canada and China out of sync with one another.

It should also be noted that, while the renewed Canadian STI Strategy announced in December 2014 did not include an international dimension except in the context of trade objectives, there will need to be significant policy coordination between Industry Canada, which leads on STI policy, and DFATD's Innovation and Asia Divisions in the roll out of the next phase of Canada-China STI relations. Science and technology are, by the very essence of discovery and innovation, international in nature. Over the coming decades, the strength and effectiveness of Canada's links with all other nations including China will be of prime importance to the fabric of Canada's economy and society.

It will be important for the two national governments to confer closely over the coming months as to how future partnerships will be managed. Canada has recently had its international STI program renewed in the form of the new Canadian International Innovation Program (CIIP), which will incent researchers in industry, universities and colleges to deepen their ties with their foreign counterparts in countries such as China, and to collaborate where there are mutual benefits. The test will be the financial commitment that the government will make to this objective. The level of funding in recent years has been barely enough to keep the relationship alive, particularly when contrasted with the significant investment in bilateral joint initiatives being made by countries such as Australia, Germany, the UK, and the US. However, now that the country has emerged from deficit, priority should be given to investing federal budget dollars in Canada's S&T relationship with a nation expected to be a leader in innovation in the coming years.

Canada has particular strengths in academic research that can provide a strong foundation for a renewed partnership. Past government investments in the Canadian networks of centres of excellence, research chairs, and research infrastructure are significant assets that Canada brings to the table. Decades of student exchanges and visiting research arrangements in both directions have improved our bilateral networks. The Canada-China Academic Forum, led by the University of Alberta and the China Scholarship Council, has identified new university arrangements to facilitate dual degrees, and Colleges and Institutes Canada is focussing increasingly on strengthening the research relationship with Chinese institutes of technology. In addition, the large Mandarin-speaking

[127] For a history of Canada/China S&T relations see Margaret McCuaig-Johnston, "The Panda and the Polar Bear: Sino-Canadian Relations in Science and Technology", a chapter included in a forthcoming book *China's Evolving International Science and Technology Relations* edited by Denis Simon, planned for publication in 2015.

diaspora in Canada provides an important asset to ease our cultural and collaborative communication. These are reasons that Canada should be seen as a natural innovation partner for China.

Nonetheless, we also need to improve our own performance in innovation if we are to be perceived as a country with which other nations want to collaborate. Countless studies have shown that Canada is falling further and further behind other nations, and our virtual absence from China's National Innovation Index illustrates that we have much work to do to be considered a country that has models of innovation of interest to China—or any other country for that matter. Companies that have visited China in the past few years have been impressed with the investments being made in all aspects of technology development and commercialisation. This is a country with which our companies should be working closely if we expect to have access to their innovations and their markets in the future. Collaboration with China cannot be developed overnight. It is an investment in time and resources that should have medium- and long-term partnerships in mind, not merely short-term trade agendas.

As discussed, despite China's massive financial STI investments, the country has had weaknesses in realizing all the expected benefits. Its STI decision-making system has been characterized by ministries managing both project selection and project management. Some have suggested that contacts were sometimes more important than merit. Furthermore, there has been insufficient communication or coordination across ministries and agencies that should have common interests in scientific research and technology development. The recently announced governance and program changes have been designed to address these problems, and Canada's experience with cross-government coordination mechanisms can provide models for China's need for systems of collaboration. Undoubtedly, the STI system will be in a transition for the next few years as the new balance of roles and responsibilities is settled. Nonetheless, President Xi will expect improvements to be shown almost immediately, and each agency and institute will be expected to produce results. Programs and opportunities will be open for business during this period of transition. This is therefore an ideal time for Canadian researchers and companies to be engaging with the new institutes and centres as they are identified, as well as with Chinese enterprises. Early and intensive efforts at engagement have the potential to place Canadian partners on the agenda of these emerging players in China's STI system as they position themselves for long-term success.

CONCLUSION

As we look forward, it is interesting to consider that the tone for China's science and technology development was established at the very first National Science Conference on March 28, 1978, when Vice-Premier Deng Xiaoping said in his opening statement that

"It is not just today, when we are scientifically and technically backward, that we need to learn from other countries—after we catch up with advanced-world levels in science and technology, we shall still have to learn from the strong points of others."[128]

Thirty-seven years later, China continues to follow this path, adopting the best technologies and models of technology development from other countries, even as it cultivates an increased capacity to develop "homegrown" innovation. In the words of the President of the NSFC, Dr. Yang Wei, "China has to transition from an economic powerhouse to a technological powerhouse and then to a scientific and cultural powerhouse."[129] As the nation progresses toward becoming a world leader in innovation, a goal it will achieve, it is in Canada's interest to collaborate with Chinese partners as naturally as we do with American scientists and innovators. It is the challenge of the Government of Canada to continue to encourage this relationship and develop vehicles for the increased engagement of researchers in companies as well as scientists in university labs, so that Canada can benefit from the advances in science and technology which are sure to come from China's huge investment in innovation. We need to do so with the full awareness of China's unique strengths and weaknesses in collaboration, while not losing our own advantages or compromising our intellectual property. This requires a long-term and robust commitment to the relationship, with clear terms of engagement understood by all.

[128] Deng Xiaoping, as quoted in Jon Sigurdson, *Technology and Science in the People's Republic of China: An Introduction*, Oxford: Pergamon Press, 1980, p. 15.

[129] Hao Xin, "New Head of China's NSF Speaks Out", March 11, 2013. Available at http://news.sciencemag.org/people-events/2013/03/new-head-chinas-nsf-speaks-out

APPENDIX

APPENDIX 1
Key S&T Ministries and Agencies

Ministry of Science and Technology (MOST)
Among government ministries, MOST has played the lead role in the Chinese S&T system for decades. (It was known as the State Science and Technology Commission before 1998.) Its prime responsibilities have included, but are not limited to: determining S&T development priorities, setting up national S&T strategies, managing S&T programs, formulating guidelines of international cooperation and drafting S&T related regulations.[130] However, in recent years MOST's role in managing R&D budgeting and overseeing civilian R&D has been reduced. Now it goes through the same budgeting process as other ministries and agencies to get appropriations from the Ministry of Finance.[131] MOST's full departmental expenditure in 2013 was 29.25B RMB or $4.68B USD. Of this, 98.7% (28.2B RMB or $4.5B USD) was spent on its S&T programs and program-related expenditures.[132] MOST funds approximately 15% of national S&T expenditures.

Within the MOST portfolio of offices is the key in-house S&T policy research and advisory group called the Chinese Academy of Science and Technology for Development (CASTED) made up of 150 professors -- 100 permanent and 50 visiting academics. CASTED played a key advisory role in considering systemic challenges and recommending the changes announced in October 2014 by the government.

Chinese Academy of Sciences (CAS)
CAS is headquartered in Beijing and comprises 104 research institutes, 12 branch academies, two universities and 11 supporting organizations in 23 provincial-level areas throughout the country. It both funds and performs research. Employing 60,000 people across all its institutes and universities, and with a budget of 42B RMB or US$6.8B, CAS has played a key research role since 1949.[133] CAS also administers aspects of some basic and applied research programs such as the 863 and 973 programs through their provision of experts for the selection committees of these programs.[134] Within CAS is the Institute for Policy and Management (CASIPM), which is the government's arms-length S&T policy advisory body.

[130] *OECD Reviews of Innovation Policy: China*, 2008, p.54. Also see MOST – Mission at: http://www.most.gov.cn/eng/organization/Mission/index.htm

[131] Yutao Sun and Cong Cao, "Demystifying central government R&D spending in China", *Science* Vol. 345, August 29, 2014, p. 1007.

[132] MOST (2014) The final accounts of MOST's budget revenue and expenditure in 2013 (in Chinese: 公共预算收入支出决算总表). Non-program related expenditures include diplomacy, social insurance, and energy-saving initiatives. Available at: http://www.most.gov.cn/czgk/czyjs/201407/P020140718531771870968.pdf

[133] CAS (2013). See: http://english.cas.cn/ACAS/BI/200908/t20090825_33882.shtml

[134] *OECD Reviews of Innovation Policy: China* (2008) and *MOST-Mission.*

National Natural Science Foundation of China (NSFC)
NSFC was founded in 1985 and its key focus is providing funding for fundamental basic research according to the National S&T Guiding Principles. At the same time, such basic research can lead to the identification of opportunities for applied research, and this too is sometimes funded. The current funding allocation from the central government to NSFC has been continuously increasing over the past decade, sometimes by as much as 20% per year. In addition, NSFC develops cooperative relations and joint funding initiatives with science foundations and granting councils in other countries and regions including with Canada (NSERC, TRIUMF) and even exchanges staff with agencies in other countries. No bureaucratic, industry or other individuals have leverage to pressure NSFC for certain decisions. There are two "Double Driving Forces": Curiosity-Driven coming bottom up from individual scientists' interests and Strategy-Driven from top-down priorities emerging from national needs.[135] Life Sciences and Health are 45% of NSFC funding. The success rate is 24-25% -- quite low by the standards of granting councils in other countries—again reinforcing NSFC's funding of high levels of excellence in the context of China's innovation system.

Other Important Players in China's S&T Governance System:

The **National Development and Reform Commission (NDRC)** is the former State Planning Commission and State Development Planning Commission. NDRC plays a significant role in the formulation of S&T policies and serves as the macroeconomic management agency under the State Council, with broad administrative and planning control over the Chinese economy.[136] In addition, NDRC affects S&T policy through its economic regulations and distribution of significant financial resources not included in its budget.[137]

The **Ministry of Education (MOE)** plays an important role in talent cultivation. For instance, MOE develops policies for education reform, and implements and coordinates national education programs in universities, such as the 211 and 985 programs. The MOE also plans, guides and funds R&D activities in higher education institutions in China, and has a direct affiliation with 75 universities.[138] And while MOST establishes national labs, MOE is responsible for their operation. In addition, many international exchanges and cooperation initiatives are under the supervision of MOE.[139] And the Ministry's Centre for Science and Technology Development is responsible for the physical and computer network infrastructure in educational institutions across the country, including 60,000 kilometres of high technology cable and 24 million users. It also manages Open Access via the

[135] NSFC. See: http://www.nsfc.gov.cn/publish/portal1/tab160/ Also, author's notes from meeting with Vice-President Shen Wenqing, August 9, 2012.

[136] NDRC. Main functions of NDRC. See: http://en.ndrc.gov.cn/mfndrc/ People's Daily Online (2012). See: http://english.people.com.cn/102759/7859408.html

[137] Yutao Sun and Cong Cao, p. 1007

[138] Ibid.

[139] MOE. See: http://www.moe.edu.cn/publicfiles/business/htmlfiles/moe/moe_2797/200907/49988.html

China Academic Library Information System, provides $1B USD funding for natural science research, and manages the IP and technology transfer policy from universities to companies under which the university owns the patent.[140]

An important institution that is affiliated with the MOE is the **China Scholarship Council (CSC)**. The CSC's objectives are to develop educational, cultural, scientific and technological exchanges and cooperation between China and other countries. The main funding source for the CSC is the State's special appropriations for the Scholarships Program which funds the CSC so that it can provide financial assistance to Chinese citizens studying abroad and foreign citizens studying in China.[141] Other countries too contribute to this interchange, such as the Canadian Bureau for International Education which works closely with CSC to coordinate efforts.

The **Chinese Academy of Engineering (CAE)** is China's premier advisory research institute in engineering. It is an independent national organization composed of elected members with the highest honor in the community of engineering and technological sciences.[142]

The **Chinese Academy of Social Sciences (CASS)** is China's highest academic research organization in the fields of philosophy and social sciences. CASS undertakes a number of research projects sponsored by the National Social Sciences Fund and defines a certain number of key projects at academy-level and institute-level according to the nation's needs for socio-economic development.[143]

The **China Association for Science and Technology (CAST)** is the largest national non-governmental organization of scientific and technological workers in China. CAST maintains close ties with Chinese scientists, engineers and other people working in the S&T field through its members and branches throughout the country.[144]

The **Ministry of Finance (MOF)** develops fiscal policies to promote R&D activities, particularly related to enterprises. In addition, the influence that it wields as keeper of the expenditure controls makes its role extremely influential in all government policy areas including S&T.

The **Ministry of Industry and Information Technology (MIIT)** and the **Ministry of Agriculture (MOA)** (and other sectoral ministries) manage R&D activities related to industrial sectors including IT and agriculture respectively. In 2008, the Commission for Science, Technology and Industry for National Defence (COSTIND), which had been responsible for the national defence planning and related policy implementation, merged into MIIT.[145]

[140] Author's notes from meeting with Dr. Li Zhimin, Director-General, Centre for S&T Development, Ministry of Education, Beijing, October 30, 2013.

[141] CSC. About us: http://en.csc.edu.cn/About/c309df7fb3fa40b3a179a7ad93f11988.shtml

[142] CAE. See: http://en.cae.cn/en/About%20CAE/Missions/

[143] CASS (2003). See: http://bic.cass.cn/english/infoShow/Arcitle_Show_Cass.asp?BigClassID=1&Title=CASS

[144] CAST. See: http://english.cast.org.cn

[145] MIIT (2008). See: http://www.miit.gov.cn/n11293472/n11459606/n11459642/11459720.html and http://english.agri.gov.cn/

The **Ministry of Human Resources and Social Security (MHRSS)** plays a role in planning talent acquisition and cultivation. For example, MHRSS is involved in the Thousand Talent Program and the drafting of plans and provision of services for international cooperation. An important program under MHRSS is the **State Administration of Foreign Expert Affairs (SAFEA)**, which facilitates exchanges of academics, researchers and others with subject matter expertise from foreign countries.

Regional S&T organizations are also important players in implementing national programs at a local level and in administering local S&T activities.

APPENDIX 2
Significant National S&T Programs

1. Key Technology R&D Program, which in 2006 became the S&T Supporting Program

The **National Program for Key Science and Technology Projects** managed by MOST was China's first national S&T program. When introduced in 1982, this program was a milestone in China's S&T development because, according to MOST, it changed China's S&T sector from "Nothing" to "Something".[146] This program was aimed at: finding solutions to S&T bottlenecks in economic and social development, promoting modernisation of traditional industries, promoting industrialisation, optimization of industrial structures, development of advanced technology, improving the quality of national economic development, enhancing S&T capacity, and improving people's lives.[147] In order to achieve these goals, the government through MOST provided funding for advanced and applicable new technologies, materials, techniques, and equipment for industrial and agricultural production and applied advanced technologies in key industries; it developed a cadre of highly qualified personnel and technical innovation centres.[148] Depending upon the needs and the merits, the program provided full financial support for projects, partial financial support, or loans.[149] Significant economic and social benefits were created through this program. The Key Technology Program also made breakthroughs in key technologies such as the Three Gorges water conservancy hub project (at the Three Gorges Dam), the Qinshan Nuclear Power Plant construction project and a large-scale ethylene project.[150]
According to MOST, the program made remarkable contributions to the technical renovation and upgrading of traditional industries and the formation of new industries during the period in which it was in force.[151] 534 projects were delivered and 2434 patents were granted.[152] The Key Technology R&D Program was revised with each Five Year Plan from 1982 to 2006 when it was replaced by the **S&T Supporting Program**. This change aimed to make the policy measures better adjust to China's new requirements for S&T development after 23 years' implementation of the initial program.

[146] MOST (2006). The Key Technology R&D Program: Provide strong support for social and economic development. In Chinese only 攻关计划：为经济和社会发展提供有力支撑 Available at http://www.most.gov.cn/kjbgz/200607/t20060706_34670.htm

[147] Consulate General of the P. R. China in Toronto. (2003, Nov. 27). Science and Technology Program In China, 2003. See: http://toronto.china-consulate.org/eng/st/20/

[148] Ministry of Science and Technology of the People's Republic of China, *R&D Programmes - Key Technologies R&D Program* See: http://www.most.gov.cn/eng/programmes1/200610/t20061009_36224.htm

[149] PRC's Toronto Consulate General, *Science and Technology Program In China.*

[150] Xinhuanet (2007). *The official launch of China's national Supporting Program.* In Chinese only 中国国家科技支撑计划正式启动. Available at: http://news.xinhuanet.com/politics/2007-02/09/content_5720550.htm

[151] MOST, *R&D Programmes - Key Technologies R&D Program.* See: http://www.most.gov.cn/eng/programmes1/200610/t20061009_36224.htm

[152] China Education and Research Network,, "The Key Technology R&D Program: implemented since 1982", 2009. See: http://www.edu.cn/project_8571/20090908/t20090908_405828.shtml

Compared to the Key Tech Program, the Supporting Program emphasized that enterprises should be the major source of indigenous innovation.[153] The S&T Supporting Program received in 2012 a MOST allocation of $1.03B USD, but with funding to projects from all sources, the total funding to all projects of the Supporting program was $2.69B USD.[154]

Research institutes, higher educational institutions, and domestic (or domestic holding) companies with strong R&D capacity are all qualified to apply to the program. According to the management guidelines for the Supporting Program, MOST is responsible for the selection process which identifies experts from universities (and sometimes companies if appropriate) to review and approve projects for funding. Agencies that have capacity for government coordination (for example, within the State Council Office, local S&T agencies and others) organize the program evaluation, the feasibility research and other activities related to the applications and projects.[155]

2. National High Technology R&D Program (863 Program)

The National High Technology R&D Program, also known as the **863 Program**, was launched in March 1986 and named with its date of establishment. This program was proposed by four senior scientists who wrote a joint letter to Deng Xiaoping, and it was established to meet the global challenges of the new technology revolution and competition. For more than two decades, the program followed the principle of "Do's and Don'ts", prioritizing projects and focussing resources on where they are most needed. The program has focussed on cutting-edge high-tech sectors in order to improve the capacity in innovation. The program is implemented through the funding of priority projects and key projects. MOST is the principal agency that directs the 863 Program. The Joint S&T Office of the 863 Program, co-managed by MOST and the PLA (for military-related applications)[156] manages the project selection process under the program. According to the Management Method document of the 863 Program, it is open to research institutes, higher education institutions and domestic (or domestic holding) companies. All of the projects require peer review prior to funding, and experts in the field are selected by MOST to sit on an 863 expert committee to select the projects (with tenure of three years, maximum two tenures).[157]

MOST has identified the objectives of the 863 Program as: 1) to boost innovation capacity in the high-tech sectors, particularly in strategic high-tech fields; 2) to strive to achieve breakthroughs in key technical fields that are vital to national security and economy; and 3) to leap-frog in key high-tech fields in which China enjoys relative advantage or should take strategic positions in order to provide high-tech support to fulfill strategic objectives in the implementation of the third phase[158] of the modernization process.[159] In addition, some 863 funding is earmarked to be assigned to projects identified and selected under the International S&T Cooperation Program, described below, where the projects are consistent with the objectives of the 863 Program.[160]

[153] Zhongguowang, *The Supporting Program promotes enterprises to be the major body of innovation*, 2007. 国家科技支撑计划 力促我国企业成为创新主体. Available at: http://www.china.com.cn/txt/2007-02/13/content_7821293.htm

[154] MOST *Annual Reports*. Available at: http://www.most.gov.cn/ndbg/2013ndbg/

[155] MOST (2006) *The temporary management of Supporting Program*. In Chinese only: 国家科技支撑计划管理暂行办法. available at: http://www.most.gov.cn/tztg/200610/t20061031_37714.htm

[156] MOST and the Chinese PLA General Armament Department set up the 'joint office'. See MOST: *The management method of 863 Program* available at: http://www.most.gov.cn/czgk/czyjs/201204/W020120425715201562626.pdf

[157] European Commission (2012). National High Technology R&D Programme (863 Programme). See: http://erawatch.jrc.ec.europa.eu/erawatch/opencms/information/country_pages/cn/supportmeasure/support_mig_0009 the link to the Joint office of the 863 program is available at: http://www.863.gov.cn/1/1/index.htm (in Chinese only)

[158] The three phases of China's modernization are: 1) the preparation phase, 2) the rapid development of modernization and 3) the consolidation of modernization (CAS report). Source: Professor Qian Chengdan, Peking University, published on Communist Party of China News, 2008. Available at: http://theory.people.com.cn/GB/49172/137777/138124/8313744.html

[159] MOST, see: http://www.most.gov.cn/eng/programmes1/200610/t20061009_36224.htm

[160] Asian Technology Information Program(ATIP) and Liu Li, *China Science: From Policy to Institutions*, http:///atip.org/atip-publications/atip-reports/2009/6512-atip09-007-china-science-from-policy-to-institutions.html p.10.

With funding from the 863 program, Chinese researchers have made significant S&T breakthroughs. According to available statistics, the 863 Program produced more than 120,000 papers and 8000 patents over more than two decades. The program also enacted more than 1900 industrial standards.[161] According to the 863 Joint Office, some breakthroughs such as high-performance computers, third generation mobile communications, the high-speed information network, deep-sea robots, super hybrid rice and many others helped China to take its place in key sectors as an innovative country. Well-known achievements such as China's participation in the human genome project, the Dawn high performance computer, and superconducting technology went some way to close the gap between China and industrialized countries.[162] Chinese researchers have mastered key technologies through 863's national investments—and these leading technologies have helped trigger the transformation of China's industrial structure and improved people's quality of life dramatically.

3. NSFC Program Funding

Approved by the State Council, the **National Natural Science Foundation of China (NSFC)** was established on February 14, 1986. NSFC reports directly to the State Council. It develops plans for basic research, funds R&D researchers, acts on the State Council's delegations, and develops joint initiatives with other ministries and with the funding agencies of many other countries,[163] such as its joint funding arrangements with Canada's NSERC and TRIUMF. Unlike many large programs that require strong research capacity and projects to be focused on national priorities, many qualified R&D researchers (belonging to registered units) are eligible to apply for this fund.[164] The most important criterion for the applicants is their scientific qualifications. For project selection, members of peer review committees of experts are identified by the NSFC, and staff support is provided to the committees in much the same way as the granting councils of Western countries operate. NSFC provides opportunities China's top scientists, as well as for applicants who are not competitive within the 863 or 973 programs. It is worth noting that, although the per project funding level for NSFC-funded projects is lower than that of the major national programs, it has a far-reaching impact since most of its funding goes to universities and research institutes (those in CAS in particular).

The 2014 planned S&T expenditure budget for NSFC (exclusive of line items such as "living insurance") was 19.28B RMB or $3.08B USD. This number is up significantly from only $12.3M USD as recently as 1986.[165] Clearly, the national government has been investing increasingly in this important agency for the delivery of the government's innovation agenda, and in the recently-announced planned reform of China's S&T programs, the NSFC is identified as a good model for program management.[166]

[161] MOST – 863 Program Joint Office. *Introduction of 863 Program*. In Chinese only. Available at: http://www.863.gov.cn/1/1/index.htm

[162] People.com (2011). 863 Plan. See: http://scitech.people.com.cn/GB/other4204/

[163] About NSFC. Available at: http://www.nsfc.gov.cn/publish/portal0/jgsz/01/

[164] National Natural Science Foundation of China. Management method of NSFC. Available at: http://www.nsfc.gov.cn/publish/portal0/tab229/

[165] NSFC budget for 2014 available at: http://www.nsfc.gov.cn/publish/portal0/xxgk/tab214/info40355.htm
NSFC budget for 1986 available at: http://www.nsfc.gov.cn/nsfc/cen/jgsz/index.htm

[166] Xinhua. "'Big surgery' for the management of programs - from government to professional institutions" 科技计划管理"大手术"：从政府直接管项目到依托专业机 Available at: http://www.most.gov.cn/sytt/201410/t20141021_116230.htm

4. Spark Program

In the same year as the 863 Program was introduced, the national government announced that it would be implementing other important programs to support the national goal of S&T development – the Spark Program (1986) and the Torch Program (1988). These two programs were designed to meet specific objectives not sufficiently covered by the other programs.

In 1986, the State Council approved the first national S&T program that aims to improve the rural economy – the **Spark Program**. This program is focussed on revitalizing rural economic development through the introduction of science and technology.[167] The Spark Program got its name from Mao Zedong's famous saying: "*A single spark can start a prairie fire*". The spark represents S&T knowledge in rural China, which starts from a single point in the vast rural areas but would potentially lever China's rural economy as a whole. In 2011, 50.3% of the population was from rural areas,[168] so it is clear that an S&T program designed to address rural issues could have significant social and economic impact. Every year the First National Document (also known as No.1 Document) always focuses on the issues of rural areas, agriculture and farmers (also known as Three rural problems or San Nong Wen Ti). The No.1 policy documents demonstrate the importance of the rural economy to the country. The priorities of the Spark Program include promoting technological change in Town- and Village-owned Enterprises, applying appropriate technology in the process of agricultural production, and improving the inflow of S&T as well as related business knowledge.[169]

The Spark Program is implemented at various levels of government jurisdiction – state (national), province, prefecture and county-level, depending upon the nature of the project. General projects within the Sparks Program are primarily managed at the provincial level, and the Spark Office within MOST is in charge of the overall planning for the Spark Program.[170]

5. Torch Program

The **Torch Program** was launched in 1988 with the objective of developing high technology and realizing its commercialisation. Aimed at the industrialization of the technologies, Torch projects are usually based on projects developed in other programs (such as the 863 Program and the Supporting Program). The Torch Program is managed at both local and State levels, and the local S&T offices select the small and medium-sized projects and report to the Torch Center at MOST, while the Torch Center selects and manages projects over 50M RMB or $8.3M USD. The funds for selected projects are allocated to local banks in the form of loans.[171]
Like the other national large-scale programs, the

[167] European Commission (2012). Spark Program. See: http://erawatch.jrc.ec.europa.eu/erawatch/opencms/information/country_pages/cn/supportmeasure/support_0015

[168] National Bureau of Statistics of China, Release of the data for the sixth national census, 2011. See: http://www.stats.gov.cn/ztjc/zdtjgz/zgrkpc/dlcrkpc/dcrkpcyw/201104/t20110428_69407.htm

[169] European Commission (2012). Spark Program. See: http://erawatch.jrc.ec.europa.eu/erawatch/opencms/information/country_pages/cn/supportmeasure/support_0015

[170] MOST, The management of Sparks Program. Available in Chinese only. 星火计划办理办法 http://www.most.gov.cn/fggw/zfwj/zfwj2002/200512/t20051214_54965.htm

[171] MOST (1994). *The management methods of the Torch Program.* available at: http://www.chinatorch.gov.cn/hjjh/zcfg/201312/481384cad3044aada168bc49d80c8d4b.shtml

Torch Program has resulted in the development of advanced technologies. In addition, the program has helped to build up national innovation clusters. Through the program, the national government have created 105 High and Emerging Technology Industry Development Zones since 1988, distributed across the country.[172] For example, the technology hub Zhongguancun China Science Park (ZCSP), also known as China's Silicon Valley, was the first state-level high-tech development zone approved by the State Council in May 1988.[173] Now ZCSP is known world-wide as China's premier science and technology development center.

Wu Wenqing and Zhang Haihong have conducted a quantitative analysis of the Torch Program's efficiency on a local basis. The result indicates that the performance is different from province to province. For example, the efficiency of Torch Program's investment in the Western areas is lower than in many other provinces. The authors conclude that factors such as the scale of the projects and the intensity of financial support could affect the efficiency at different levels. Therefore it is hard to find a 'one size fits all' national strategy, particularly for programs that are implemented at the local level.[174]

6. National Basic Research Program (973 Program)

On June 4, 1997, in order to strengthen basic research in line with national strategic targets, the Leading Group of the State Council decided to formulate the National Plan on Key Basic Research and Development, known as the **973 Program** to strengthen basic research in key S&T areas.[175] In implementation, MOST adopts a "2+3" mode for this Program, which means after two years' implementation of a project, a mid-term evaluation of the project will be conducted. Based on the results of the evaluation, a decision will be made either to continue the project or to adjust the funding over the next three years.[176] Similar to other large national S&T programs, the 973 Program accepts applications from research institutes, higher education institutions and companies with strong R&D capacity in mainland China.[177] The expert committee for this program conducts the selection of projects. The Management Method also requires a chief scientist who takes the lead on the project. In 2013, about $0.68 billion USD was invested in this program.

The 973 Program has had significant achievements over the years, particularly in the fields of nanoscience, quantum information and life sciences.[178] MOST has concluded that 973 has

[172] MOST (2012). Torch High Technology Industry Development Center. Chronology notes. See: http://www.chinatorch.gov.cn/kjb/zxjj/about.shtml

[173] China Daily (2011). Zhongguancun China Science Park. See: http://en.zgc.gov.cn/2011-11/14/content_14025989.htm

[174] Wu Wenqing, Zhang Haihong, "Efficiency and Spatial Correlation of National Torch Program Projects among Chinese Provinces" in *Advances in Information Sciences and Service Sciences*. 5(10), 2013. pp 406-413. Available at: http://www.aicit.org/AISS/ppl/AISS3444PPL.pdf

[175] MOST. Key Technologies R&D Program. see: http://www.most.gov.cn/eng/programmes1/200610/t20061009_36224.htm

[176] Profile of 973 Program. National Basic Research Development Program. See: http://www.973.gov.cn/English/Index.aspx

[177] MOST. The management of 973 Program. In Chinese only. 关于印发国家重点基础研究发展计划管理办法的通知. Available at: http://www.most.gov.cn/tztg/201112/t20111209_91296.htm

[178] 973 Program. MOST. The implementation status of 973 Program. In Chinese only 国家重点基础研究发展计划（973计划）组织实施情况. Available at: http://www.973.gov.cn/ReadCont.aspx?aid=419

boosted basic research and applications in the fields of aerospace materials engineering, proteomics of human diseases as well as deep rock mechanics, and has built up a solid foundation for the sustainable development of China's science and technology.[179]

7. Knowledge Innovation Program and other Talent Acquisition Programs

The **Knowledge Innovation Program (KIP)** was established in 1998 by the Chinese Academy of Science. The fundamental objective of this program was to increase the knowledge capacity of CAS and improve the whole country's capacity in innovation.[180] The KIP was implemented in three phases: 1) initialization phase (1998 -2000); 2) comprehensively promoting phase (2001-2005) and 3) adjustment phase (2006 - 2010).[181] Professor Richard Suttmeier has indicated that with the funds of KIP, CAS was able to make a series of institutional improvements such as hiring more highly talented people and funding more R&D institutes.[182] In the same paper he concluded that 70% of the KIP funding was distributed to the institutions and 30% stayed with CAS. The KIP program undoubtedly enhanced CAS's capacity in science and technology. For example, from 1998 to 2004 (within the first two phases of implementation) among all the national programs, CAS undertook 122 projects under the 973 Program (36% of the program funding); CAS was also in charge of 48 NSFC major projects (52% of the program funding) and 365 NSFC key projects (32% of the program funding).[183] However, critiques such as overstaffing, low efficiency in funding R&D institutes, and imposition of top-down requirements also made KIP's success mixed.[184]

According to CAS, in March 2010, Premier Wen Jiabao decided to deepen the KIP program at the 105th Executive meeting of the State Council. The new program that replaced KIP is called 'Innovation 2020', placing CAS on the government's agenda for realizing the leapfrog in innovation by 2020.[185]

The **Hundred Talents Program** and the **Thousand Talents Program** are important components of China's revitalization plan for its highly qualified human resources. It is well known in China that it has suffered from a 'Brain Drain'.[186] Dr. Mu Rongping, Director of the CAS Institute for Policy and Management, has suggested in his April 12, 2013 speech at the Research Institute of Economy, Trade and Industry (REITI) that innovation in the field of human resources should be implemented on a multilevel and diverse scale.[187]

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179 See MOST: http://www.most.gov.cn/eng/programmes1/200610/t20061009_36224.htm

180 Institute of Geosciences and Resources, CAS (2005). Brief introduction of KIP. 中国科学院知识创新工程简. Available at: http://www.igsnrr.cas.cn/cxwh/cxdt/200505/t20050525_1784973.html

181 CAS (2012). The Knowledge Innovation Program. Available at: http://www.lssf.cas.cn/cxgc/

182 Richard P. Suttmeier, Cong Cao and Denis Fred Simon (2006). "Knowledge Innovation" and the Chinese Academy of Sciences. Science. Vol (312). Available at: http://www.ibcas.ac.cn/zhxw/200604/P020090320351160082440.pdf

183 Seven Years' Pilot of KIP – CAS has made a series of significant achievement. In Chinese only. 知识创新工程试点7年 中科院取得一批重大成果. Available at: http://scitech.people.com.cn/GB/1056/3266413.html

184 Critiques see: Richard P. Suttmeier, Cong Cao and Denis Fred Simon,"Knowledge Innovation" and the Chinese Academy of Sciences, 2006; and Jane Qiu (2011), "China Sets 2020 Vision for Science", *Nature*, 2011, 470(15) p.58-59.

185 Jane Qiu, "China Sets 2020 Vision for Science", *Nature*, 2011, 470 (15). Noted by the author, "Innovation 2020 will kick off with new projects this year in seven key areas, including nuclear fusion and nuclear-waste management; stem cells and regenerative medicine; and calculating the flux of carbon between land, oceans and atmosphere. Other priority areas include materials science, information technology, public health and the environment".

186 Wang Huiyao (2012). China's Competition for Global Talents: Strategy, Policy and Recommendations. Asia Pacific Foundation of Canada Research Report, p.5.

187 Mu Rongping. Innovation-driven Development in China: Strategy, Policy and Practices. "In the next five or ten years, there will likely be some very important changes in policy regarding science and technology innovation. It is crucial that the policies for innovation development should focus on four key issues so as to explore and energize the people's potential for innovation. The first issue is that of innovation capacity building. The second issue is that of developing linkage and coupling among all of the key players associated with the development of innovation. The third important issue is innovation in the field of human resources on a multilevel and diverse scale. Finally, it is important for China to focus on developing the institutional environment in order to improve the levels of motivation and the sense of security in the public." Available at http://www.rieti.go.jp/en/events/bbl/13041201.html

As the pioneer of China's talent acquisition programs, since its start in 1994, the Hundred Talents Program has introduced and cultivated 2145 outstanding scientists and moved CAS's talents to a younger generation. The Thousand Talents Program, which started in 2008, has introduced 4180 talents to date.[188] It focuses on introducing overseas educated Chinese and foreign high-level talent to the Chinese R&D environment in order to develop more advanced innovation. The Thousand Talents Program is managed by a coordinating working group that is comprised of a number of organizations including the Organizational Department of the Central Committee of the Communist Party of China, MHRSS, MOE, MOST, People's Bank of China, SASAC, CAS, CAE, NDRC, MIIT and others.[189]

8. Innovation Fund for Small Technology-based Firms (Innofund)

In June 1999, a special fund called the Innovation Fund for Small Technology-based Firms (the Innofund for SMEs) was established to cultivate technology-based SMEs by supporting innovation, and facilitating and transforming their R&D results.[190] With the assistance of local governments, MOST and MOF collaboratively fund technology-based SMEs and supervise their performance. From 1999 to 2013, a total of 26.8 billion Yuan ($4.4 billion) was spent through the Innofund to support innovation by SMEs.[191] The forms of the support of the Innofund are diverse: funds, loans and subsidies are provided based on the needs of each project.[192]

9. R&D Infrastructure and Facility Development Program

The R&D Infrastructure and Facility Development Program was launched in 2005 to provide needed infrastructure support for the R&D environment. The National S&T Center under MOST manages the program.[193] It includes a series of sub-programs such as the State Key Laboratories Development Program, National Key Science Projects Program, National Engineering Technology Research Centers Development Program R&D Infrastructure and Facility Development Program, S&T Basic Work Program, Program on Research for Public Good, and Program on Key International S&T Cooperative Projects.[194] There is also a comprehensive infrastructure program managed by the Ministry of Education, focussing in particular on the IT network infrastructure necessary for research as well as infrastructure needs of universities and schools across the country.

10. National Major Projects Program (NMP)

The National Major Projects (NMP) Program, as its name implies, is a program focused on a limited number of large projects that are key to the nation's overall development. The projects are selected according to the prioritized fields in China's National Medium- and Long-term Program for S&T Development (2006-2020) (MLP). MOST has put a lot of emphasis on key projects because they are considered to be an important measure to enhance national competitiveness.[195]

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[188] Sun Yinglan (2014). From the Hundred Program to Thousand Program and Ten-thousand Program – understand China's history of Talent introduction. 从“百人计划”、“千人计划”到“万人计划”， 带你读懂国家知名引才计划的发展. Available at: http://www.1000plan.org/qrjh/article/59238

[189] 1000Plan.com. The Recruitment Program of Global Experts. Available at: http://www.1000plan.org/qrjh/section/2?m=rcrd

[190] European Commission (2012). Innovation Fund for Small Technology-based Firms. See: http://erawatch.jrc.ec.europa.eu/erawatch/opencms/information/country_pages/cn/supportmeasure/support_mig_0010

[191] ChinaDaily (2013). China spends big to support SME innovation. See: http://www.chinadaily.com.cn/bizchina/2013-10/26/content_17060358.htm

[192] Innofund. Forms of Finance. Available at: http://www.innofund.gov.cn/english2/xhtml/04_forms_of_financing.htm

[193] National S&T Center. Center's Function: http://www.nstic.gov.cn/l-side/brief.jsp

[194] European Commission (2012). R&D Infrastructure and Facility Development Program. See: http://erawatch.jrc.ec.europa.eu/erawatch/opencms/information/country_pages/cn/supportmeasure/support_mig_0005 and MOST. National Science and Technology Infrastructure Program. http://www.most.gov.cn/eng/programmes1/200610/t20061008_36200.htm

[195] MOST, "The National Major Projects: Program introduction. Available at: http://www.nmp.gov.cn/zxjs/

Established in 2006, the NMP supported sixteen projects initially (reflected in the MLP) and is now focussed on thirteen. The program indicates that it endeavours to achieve technology breakthroughs and resource integration. The outlined projects include both science and engineering disciplines and cover the following fields: 1) core electronic devices, high-end general chips & basic software products, 2) integrated circuit (IC) equipment, 3) broadband Mobile Communication, 4) numerically-controlled machine tool, 5) oil and gas development, 6) large-scale nuclear power plant, 7) water pollution control, 8) transgenosis technology, 9) drug discovery, 10) control of communicable diseases (HIV/AIDS and viral hepatitis etc.), 11) large aircraft, 12) high-resolution earth observation systems, and 13) manned spacecraft and the moon exploration.[196]

In 2012, 12.85B RMB or $2.06B USD from the central funds was "involved" in the major projects. In 2011 the "involved" central funds were 24B RMB or $3.8B USD.[197]

11. Program for Key International S&T Cooperation Projects

The Program for Key International S&T Cooperation Projects Program, created in 2001, is the most important platform for the country to partner with other nations on science, technology and innovation, as well as China's participation in multilateral S&T projects involving international organisations. As such, it is of particular interest to the policy departments, funding agencies, companies and researchers in partner countries such as Canada. Indeed, China's S&T Agreement with Canada was its 100th agreement with other nations. The program is managed by the Department of International Cooperation of MOST which is responsible for formulating policies, organizing bilateral and multilateral S&T cooperation, selecting experts for the project selection committees, and guiding relevant government agencies in their implementation of elements of the program.[198] As mentioned above, funding outside this program is available to fund partnerships with other countries via international projects; the 863 Program has earmarked funds available to facilitate the integration of 863 with the International S&T Cooperation Projects to support and encourage the implementation of international cooperative projects within the framework of the 863 program.[199]

In 2012, 329 international projects were approved. Companies, higher education institutes and R&D institutes each take about one-third of the projects respectively. Public funding for the 2012 program funding was $0.19 billion USD and this was matched by $0.5 billion USD from other sources.[200] To develop and maintain connections with its counterparts in other countries, China has stationed 144 S&T diplomats in 70 institutions and 47 countries.[201] Under this program, China has partnered with Canada in recent years on two dozen projects in fields such as human vaccines, electric vehicles, agriculture technologies and medical devices.

[196] Central Government. MLP Chinese version. http://www.gov.cn/jrzg/2006-02/09/content_183787.htm

[197] Note that the wording for NMP's budget figures is 'involved' – not 'funded'.

[198] Swissnex, pp. 6-7.

[199] ATIP, p.10.

[200] MOST 2013 Annual Report - International S&T Cooperation Program. Available at: http://www.most.gov.cn/ndbg/2013ndbg/201404/P020140422512365460878.pdf

[201] Denis Fred Simon, "Key Drivers Underlying China's International S&T Relations: Presentation to the President's Council of Advisors on Science and Technology", May 9, 2014, pp. 13,14.

APPENDIX 3
China's Ranking on the Indicators of the National Innovation Index 2013

Primary Indicators: NII Report 2013, p.22

Table 2-1 China's ranking in the primary indicators of the national innovation index

Year	Innovation resources	Knowledge creation	Enterprise innovation	Innovation performance	Innovation environment	Innovation index ranking
2005	31	37	17	17	27	25
2006	32	34	17	16	28	25
2007	33	34	14	13	27	22
2008	33	33	12	9	23	21
2009	31	32	18	6	16	22
2010	30	29	15	5	18	20
2011	30	24	15	5	19	20
2012	30	18	15	14	14	19

Secondary Indicators: NII Report 2013, p.42

Table 3-1 China's world rankings in the secondary indicators of the innovation performance index

Year	Labor productivity	GDP per unit of energy use	Number of patents in force	High-technology exports as a percentage of manufactured exports	Value added of knowledge-intensive industries as a percentage of the world's total
2000	39	38	–	16	6
2001	39	36	–	13	6
2002	39	37	–	10	6
2003	39	39	–	6	7
2004	39	39	–	6	6
2005	39	39	6	6	6
2006	39	40	6	6	6
2007	39	40	5	6	5
2008	39	38	4	6	3
2009	39	37	4	4	3
2010	39	37	4	3	3
2011	39	37	4	2	2
2012	39	36	4	2	2

APPENDIX 4
State Council:

"Opinions on Improving and Strengthening the Management of Scientific Research Programs and Funds Financed by the Central Financial Budget"[202]

On March 12th, 2014, the State Council published the Opinions on Improving and Strengthening the Management of Scientific Research Programs and Funds Financed by the Central Financial Budget (hereinafter the Opinions). The background analysis of Opinions[203] from MOST has pointed out the following problems in R&D program and funding management:

• There are many duplicative and decentralized arrangements of current scientific programs;
• There is a lack of full transparency in program management. There are violations of regulations in the use of funds; and
• The management of S&T funds has not adapted to the rapid growth of scientific research funds, and the efficiency of financial resource management needs to be improved.

The Opinions propose the following measures to address these issues.

1. Strengthen the coordination and allocation of funds/resources (for R&D projects)

• Optimize and integrate various special funds and programs.
• The methods include establishing performance evaluation, dynamic adjustment, and termination mechanisms.
• Programs with unclear positioning, duplication and overlap or ineffective performance shall be eliminated, integrated or transformed.
• The communication and consultation mechanisms among related departments regarding the major S&T issues shall be improved.
• The S&T authority and finance authority shall establish the unified national S&T management information system. The database of central and local scientific projects should be integrated by the end of year 2015 and open to the general public.

2. Manage the programs in separate categories

• Highlight innovation for basic research on cutting-edge scientific research projects.
• Fully respect the views of experts; support young researchers; encourage exploration and tolerate failures.

[202] This English version covers key subjects and highlights and is not a translation of the full document. The original Chinese of the State Council's Opinions document is available at http://www.gov.cn/zhengce/content/2014-03/12/content_8711.htm
This translation of highlights by Moxi Zhang is based on the original document and referenced to some of the terms used by the European Commission (EC) in its summary of the Opinions. See EC link at: http://ec.europa.eu/euraxess/index.cfm/links/singleNews/46477
[203] MOST. 'Background of the Opinions'. April 14, 2014. Available at: http://www.most.gov.cn/ztzl/zyczkyxmzjglyj/yjbj/201404/t20140414_112691.htm

• Let the market play its guiding role in directing R&D and allocating resources
• Reinforce the role of enterprises for market-oriented projects; clarify the boundaries between government and market.
• The ratio of experts from enterprises should be increased for the evaluation of market-oriented projects.
• Major projects should reflect national objectives: 'Concentrate the power on big things' - resources should be concentrated on significant issues and key breakthroughs.

3. Improve the management process of R&D programs

• Reform the project guidelines and regulate the selection of projects; project application time should be no less than 50 days in principle
• Project packaging and "forced partnering" should not be allowed
• Standardize the selection of projects. The program administration authorities should optimize the competitive selection mechanism and select projects on an open, fair basis. In principle, the evaluation cycle should be no longer than 120 working days.
• The selection of projects should be checkable, traceable and appealable.
• Improve review of results through peer review or third party evaluation.

4. Improve the management of funds

• Management authorities shall not apply budget control in advance to the project applications (exception: fixed subsidies); the budget should be determined according to the actual needs and local conditions.
• Indirect subsidies shall be linked to credit evaluation.
• Spending for performance should fully reflect the value of researchers.

5. Enhance the regulation of research projects and funds

• Regulate the use of funds for scientific projects by improving the billing system and implementing heavier penalties of violation.

6. Establish & improve the basic system (information disclosure and technical reports)

• Disclose information for projects and financial management as much as possible.
• Improve the selection system of experts; implement the rotation system of experts in evaluation; absorb the front-line researchers and overseas high-level experts. The portion of front-line researchers should reach approximately 75%.
• Further mobilize the researchers - encourage two-way communication and exchange among research institutes, universities and companies.
• Improve S&T evaluation and reward systems, as well as the R&D tax system. Incentives should be closely linked with their position responsibilities, work performance, and practical contributions.

7. Enhance the responsibility of relevant authorities in the implementation of the policies

APPENDIX 5
Existing Arm's Length Organisations of MOST

The following are the types of organizations that could become 'third' party institutes or institutions in this reform, or could be combined with others to create a new institute.

国家科学技术奖励工作办公室	National Office for Science and Technology Awards
中国科学技术信息研究所	Institute of Scientific and Technical Information of China
科学技术部科技人才交流开发服务中心	Science and Technology Talents Exchange, Development and Service Center, MOST
科学技术部机关服务中心	Service Center of MOST
中国农村技术开发中心	China Rural Technology Development Center
科学技术部火炬高技术产业开发中心	Torch High Technology Industry Development Center, MOST
中国技术市场管理促进中心	China Technology Market Management and Promotion Center
科学技术部科技型中小企业技术创新基金管理中心	SME Technology Innovation Fund Management Center, MOST
中国生物技术发展中心	China National Center for Biotechnology Development
科学技术部高技术研究发展中心（科学技术部基础研究管理中心）	High Technology Research and Development Center, MOST / Basic Science and Technology Management Research Center, MOST
国家遥感中心	National Remote Sensing Center of China
科学技术部科技经费监管服务中心	Supervision Service Center for Science and Technology Funds, MOST
中国国际核聚变能源计划执行中心	China International Nuclear Fusion Energy Program Execution Center
中国科学技术发展战略研究院	Chinese Academy of Science and Technology Development (CASTED)
中国科学技术交流中心	China S&T Exchange Center
中国21世纪议程管理中心	The Administrative Center of China's 21 Century Agenda
国家科技基础条件平台中心	National Science and Technology Infrastructure Center
科学技术部科技评估中心	National Center for Science and Technology Evaluation, MOST
国家科技风险开发事业中心	National Science and Technology Venture Capital Development Center

Source: Chinese language website of MOST: www.most.gov.cn

LIST OF ACRONYMS

CAE	Chinese Academy of Engineering
CAS	Chinese Academy of Sciences
CASIPM	Institute for Policy and Management, CAS
CASS	Chinese Academy of Social Sciences
CAST	China Association for Science and Technology
CASTED	Chinese Academy of Science and Technology for Development
CBRC	China Banking Regulatory Commission
CIIP	Canadian International Innovation Program
CCPCC	Chinese Communist Party Central Committee
COSTIND	Commission for Science, Technology and Industry for National Defence
CPC	Communist Party of China
CSC	China Scholarship Council
DRC	Development Research Centre (of the State Council)
EC	European Commission
FTEs	Fulltime equivalents
GERD	Gross domestic expenditure on research and development
HIV/AIDS	Human immunodeficiency virus/ Acquired immunodeficiency syndrome
HQP	Highly Qualified Personnel
IC	Integrated circuit
ICT	Information and communications technology
IP	Intellectual Property
IQ	Innovation Quotient
IRAP	Industrial Research Assistance Program
ISTCP	International S&T Cooperation Program
ISTIC	Institute of Scientific and Technical Information of China
KIP	Knowledge Innovation Program
MHRSS	Ministry of Human Resources and Social Security
MIIT	Ministry of Industry and Information Technology
MLP	Medium- and Long-term National Plan for Science and Technology Development 2006-2020

MNEs	Multinational Enterprises
MOA	Minister of Agriculture
MOE	Minister of Education
MOF	Minister of Finance
MOH	Ministry of Housing and Urban-Rural Development
MOST	Minister of Science and Technology
MOU	Memorandum of Understanding
NDRC	National Development and Reform Commission
NHFPC	National Health and Family Planning Commission
NMP	National Major Projects Program
NRCSTD	National Research Centre for Science and Technology Development
NSERC	Natural Sciences and Engineering Research Council of Canada
NSFC	National Natural Science Foundation of China
OECD	Organisation for Economic Co-operation and Development
PRC	Peoples' Republic of China
R&D	Research and development
REITI	Research Institute of Economy, Trade and Industry
RMB	Renminbi
S&T	Science and Technology
SAFEA	State Administration of Foreign Expert Affairs
SASAC	State-owned Assets Supervision and Administration Commission of the State Council
SIPO	State Intellectual Property Office (China)
SMEs	Small and medium-sized enterprises
SOEs	State-owned enterprises
STI	Science, technology and innovation
TCP	Technology Partnerships Canada
TRIUMF	Canada's national laboratory for particle and nuclear physics
USD	United States dollars
ZCSP	Zhongguancun China Science Park
863 Program	National High Technology R&D Program
973 Program	National Basic Research Program

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