Securing Australia's Future - Project 9
Translating research for economic and social benefit: country comparisons

China

Measures that facilitate transfer of knowledge from publicly funded research organisations to industry in China

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Executive Summary

Since the 1980s, when China adopted a market-oriented economic mechanism, the transformation of research achievements into productivity and social and economic benefits has become a national strategic priority. As the Chinese economy has boomed in the last two decades, China has emerged as an important scientific power, and rapid economic growth has resulted in substantial investment in R&D in China. China has excelled at mobilising resources for science and technology (S&T) on an unprecedented scale and at exceptional speed, with an annual growth rate of 14.8% between 2010 and 2013, and these enterprises are playing a leading role in the system of national innovation. Within the total GERD, ￥907.6 billion (76.7%) originated in the business sector, ￥178.1 billion (15.0%) was sourced from public research institutes, and ￥85.7 billion (7.2%) came from institutions of higher education (HEIs). China has also become the world's largest reservoir of R&D personnel. In 2013, more than 5 million people were involved in various types of R&D activities.

In order to facilitate the development of S&T in China and promote the transformation of research achievements for social and economic benefits, a crucial institutional foundation consisting of independent agencies has been established at all levels and constitutes a top down, multi-layer, and interactive administrative system in China. The key national agencies responsible for the transformation of research achievements include the State Council, the Ministry of Science and Technology, the Ministry of Education, and the Ministry of Finance. In 2011, the National Fund for Technology Transfer and Commercialization was established with the goal of improving support for the transfer of research outputs. The transformation of S&T achievements has been prioritised as a national strategy and its importance was emphasised in both the *National Mid-Long-Term Science and Technology Development Framework (2006-2020)* and the *National Mid-Long-Term Education Reform and Development Framework (20010-2020)*. In addition, several laws and regulations have been enacted to provide legal guidance and guarantees for the transformation of research achievements in China. The amendment of the *Law of the PRC on Promoting the Transformation of Scientific and Technological Achievements* has just been approved, in order to better accommendate the need for the transfer of research output.

In terms of the programmes and plans launched to promote the transformation of research achievements in China, the report documents four major national programmes, including the Spark Programme, the Science and Technology for Wellbeing Programme, the Torch Programme, and the Blue Flame Programme. All four programmes have various focuses and have yielded considerable results. The report provides details about the government's investments in each programme, the administration, goals, mission, and purposes of the programme, and the evaluation process for them. It should be noted that the report does not exhaust all of the national programmes designed to facilitate the tranformation, or the measures employed by different provincial and municipal governments.

At the university level, policies have also been issued to encourage entrepreneurship among students and staff. In this report, the case of Nankai University serves as an example. An interview was conducted with a Programme Manager in the Technology Tranfer Office of the university to explain in what ways the university advocates innovation on campus and enhances the collaboration between the university and local government and enterprises. Because universities, Research Institutes (RIs), and companies are the primary actors in the system of national innovation, the Chinese government has been committed to enhance that collaboration since 1979. Many research universities have developed closer links to industries through various forms of collaboration, including university-affiliated technology enterprises, technology transfer contracts, patent licensing, joint-authored publications and the university Science Park. The example of the Brainbridge Program, which is operated jointly by Royal Philips Electronics, Zhejiang University, and the Technical University of Eindhoven (Netherlands) illustrates the various ways that universities can cooperate with enterprises.

Although China has made spectacular achievements in translating research into social and economic benfits, it should be recognised that there remain problems and difficulties, such that a technology commercialisation system needs to be established to better promote the transformation of research achievements in China.

1. Overview

China, officially the People's Republic of China (PRC), is the world's most populous country, with a population of over 1.37 billion.[1] After the foundation of the PRC in 1949, the introduction of modern S&T became one of the new government's top priorities. In the 1950s, China promoted R&D that centred on the fields of defence and heavy industry under a highly centralised governmental system modelled after the former Soviet Union.[2] With the launch of the "opening up" policy in 1978, a slogan was proposed, that "science-technology is the chief productive force, knowledge and talent shall be respected."[3] For the first time in China's history, S&T were viewed as driving forces behind economic development. The Chinese government began to shift away from the inefficient Soviet style of technology innovation to a new system that motivates the participation of all parties: research institutes, universities, and enterprises.

Giants of science emerge when a society's economy becomes extraordinarily robust by world standards. France, Germany, Britain, and the US are examples. An evolving multi-polar world economy has led to multiple centres of science. The average annual GDP growth rate was 9.8 per cent during the period 1978-2013, and reached ¥63.65 trillion (approximately AUD12.73 trillion at the current exchange rate) in 2014.[4] Like any developing country, the financial investment in R&D is a decisive factor in the progress of S&T in China, and government allocations play an important role. Figure 1 shows gross expenditures on science-related R&D (GERD) in China from 2010 to 2014. China has excelled at mobilising resources for S&T swiftly and on an unprecedented scale, with an annual growth rate of 14.8% between 2010 and 2013. In 2014, GERD reached ￥1,331.2 billion (approximately AUD266.2 billion at the current exchange rate), an increase of 12.4 per cent over the previous year. The intensity of R&D (R&D expenditure as a percentage of GDP) was 2.09%.[5] The 2013 GERD in all sectors of the economy was ￥1,184.7 billion, with an R&D intensity of 2.01%. This number made China the second-largest R&D performer after the US, and ahead of Japan, Germany and Korea.[7] The R&D intensity of China exceeded the average of the European Union (1.92%), but remained lower than that of Japan (3.49%), Germany (2.94%), the US (2.81), and the OECD average (2.40%).[6]

Enterprises are playing a leading role in the national innovation system. Among the total GERD, ￥907.6 billion (76.7%) came from the business sector, ￥178.1 billion (15.0%) was sourced from public research institutes, and ￥85.7 billion (7.2%) originated from HEIs. With respect to the type of activities, the majority of GERD was directed to experimental development (84.6%), followed by applied research (10.7%). Basic research received less funding than the other two, and constituted only 4.7% of total GERD.[7]

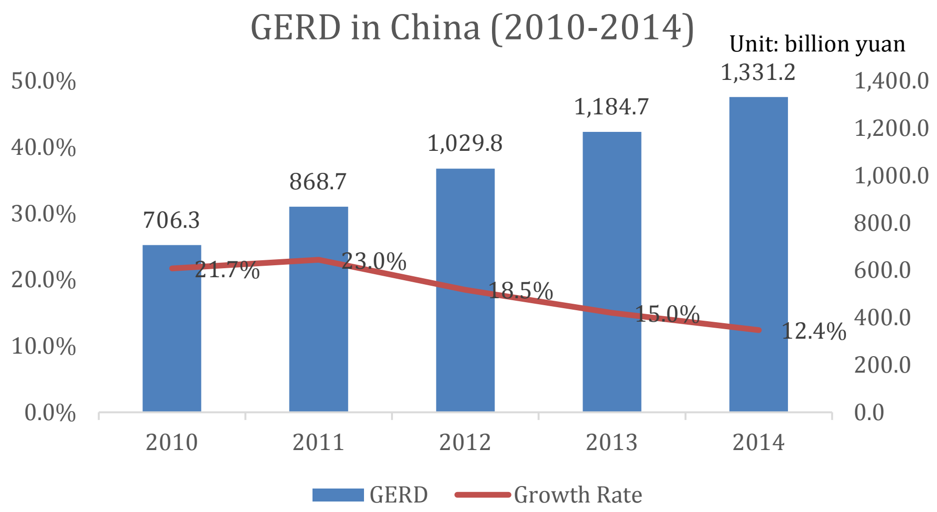

Figure 1: GERD in China (2010-2014)

With respect to China's large reservoir of R&D personnel, more than 5 million people were involved with various kinds of R&D activities in 2013, an increase of 8.8 per cent over the number in 2012. Among them, 18.9 per cent held higher research degrees, and another 27.7 per cent held bachelor's degrees. These R&D personnel were distributed across different sectors. The majority (67.3 per cent) conducted R&D activities in enterprises, followed by the higher education (HE) sector (9.2 per cent). It is worth noting that the proportion of R&D personnel in the HE sector declined from 18.4% in 2004 to 9.2% in 2013. The full-time equivalent (FTE) accounted for 70.4 per cent of the total R&D personnel in China, with 8.8 per cent growth over that in 2012. Figure 2 presents the growth of R&D personnel (FTE) in China between 2004 and 2013. Despite this accomplishment, the density of R&D personnel in China remains lower than that in other developed countries, even if China is rapidly closing the gap. In 2013, the number of R&D personnel per ten thousand employees in China rose from 32.6 in 2010 to 45.9 in 2013, while the number of researchers per ten thousand employees grew at a slower rate, from 15.4 in 2010 to 19.3 in 2013. These numbers show that in terms of R&D personnel, China has outperformed most developing countries, including Turkey, Argentina, and South Africa, but remains far behind Finland, Germany, and France (Table 1).[8]

Figure 2: R&D personnel in China (2004-2013)

Table 1: R&D personnel in different countries

Country	Year	R&D personnel (ten thousand person year)	R&D personnel per ten thousand employees (person year/ten thousand person)
China	2013	353.3	45.9
Finland	2012	5.4	213.0
Korea	2012	39.6	160.4
Japan	2013	86.6	133.5
France	2012	40.2	148.7
Canada	2012	22.4	125.4
UK	2013	36.2	120.9
Germany	2013	59.1	140.7
Greece	2013	82.7	115.8
Russia	2013	82.7	115.8
Turkey	2013	11.3	44.3
Argentina	2012	7.2	41.1
South Africa	2012	3.5	24.3
Mexico	2007	7.0	16.5

This high level of national investment has contributed to China's outstanding achievements in S&T. In 2013, the Chinese S&T papers indexed by SCI reached 231,400, making China the 2nd ranked in the world. Among them, Chinese scholars as first authors of papers accounted for 88.2 per cent, an increase of 23.9 per cent over that in 2012. The top ten disciplines include chemistry, clinical medicine, physics, biology, material science, preclinical medicine, mathematics, geoscience, computing technology, and electronic communication and automatic control. Figure 3 shows the growth of Chinese S&T papers indexed by SCI between 2000 and 2013.[9] Among all of these papers in 2013, 56,076 were internationally co-authored and comprised 24.3% of the total. The co-authors came from 138 countries and regions. The top six were the US, Australia, UK, Canada, Japan, and Germany.[10]

In 2013, there were 2.38 million patent applications, an increase of 15.9 per cent over 2012; 1.31 million were granted. 15.8% of these patents were for inventions, 52.8% were patents of utility models, and 31.8% were appearance design patents. The majority of patent applications came from the business sector (60.6%). In addition, 22,000 PCT international patent applications originated in China in 2013, an increase of 15.5% from 2012. This was the first time that applications in China exceeded those in Germany, and made China the 3rd ranked in the world. In addition, tripartite patent ownership is used typically as an indicator of the quality and competitiveness of patents. According to OECD figures, China owned 1,851 tripartite patents in 2012, and thus ranked 6th in the world.[11]

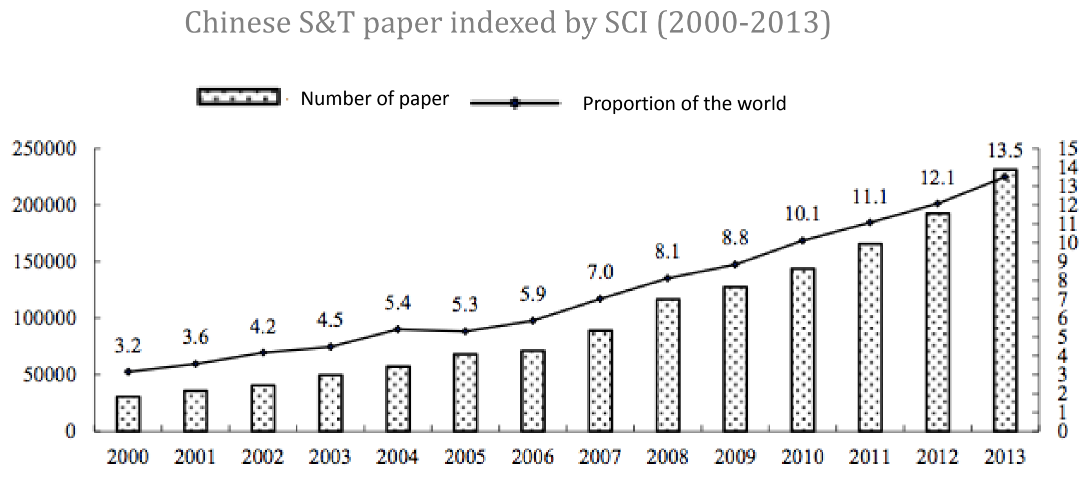

Figure 3: Chinese S&T papers indexed by SCI (2000-2013)

2. Key national agencies for the transformation of research achievements

In order to facilitate the development of S&T in China and promote the transformation of research achievements for social and economic benefits, an institutional foundation consisting of independent agencies has been established at all levels down to counties, and constitutes a top down, multi-layer, interactive administrative system in China (Figure 4).

The State Council is the chief administrative authority of the PRC. It is chaired by the Premier and includes the head of each governmental department and agency. There are 25 ministries and 38 centrally administered government organisations that report to the State Council directly. The State Council also oversees the various subordinate People's governments in the provinces directly. The State Council is responsible to the National People's Congress, and conducts a wide range of government functions, both at the national and local levels, including S&T development and the translation of research achievements.[12]

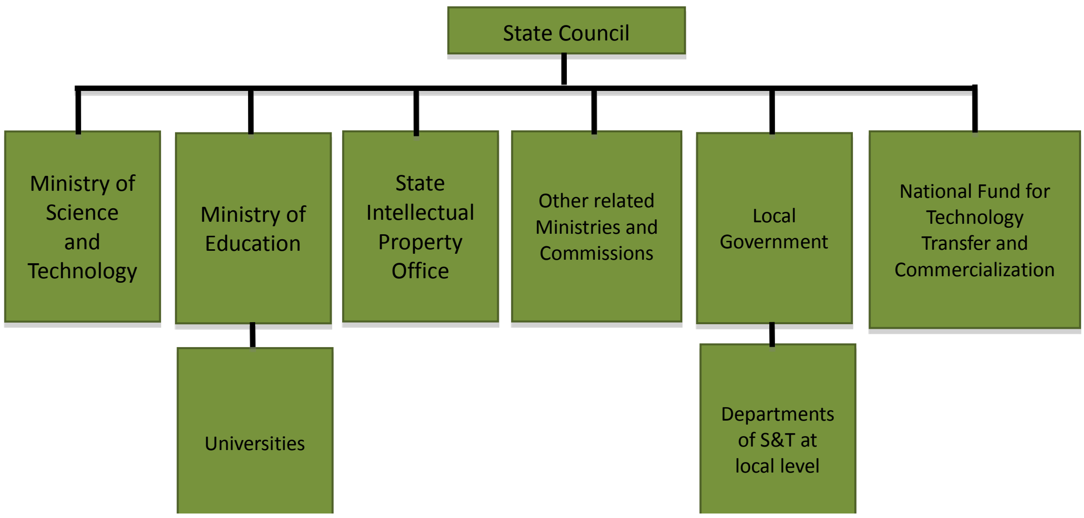

Figure 4: Key agencies for S&T development and the transformation of research achievements

2.1 Ministry of Science and Technology

The Ministry of Science and Technology (MoST) is the most important national agency in the development of S&T policies in China. The national programs that have been launched to promote the transformation of research achievements are administered, managed, and evaluated primarily by the MoST. Specifically, the missions of the MoST include:

- Taking the lead in drawing up S&T development plans and policies, drafting related laws, regulations, and department rules, and guaranteeing implementation.

- Being responsible for drafting the National Basic Research Programme, the National High-tech R&D Programme, and the S&T Enabling Program.
- Collaborating with other organisations in scheme demonstration, assessment, acceptance, and policymaking for major S&T special projects, and providing advice on significant changes.
- Developing and implementing plans for national laboratories, innovative bases, national S&T programs, and research conditions in order to promote infrastructure construction and resource sharing.
- Formulating and supervising S&T plans according to policies, drafting policies on hi-tech commercialisation with other departments, and guiding the national high-tech industrial development zones.
- Drawing up policies and measures to enhance social progress in S&T in rural areas to improve the livelihoods of the people.
- Issuing policies to encourage the synergy of enterprise, university and research institutes, promoting the application and demonstration of scientific discovery and technological inventions, and improving enterprises' capacity for innovation.
- Making proposals on institutional reforms and supervising the establishment and restructuring of research institutes.
- Being responsible for budgeting, final accounting, and oversight of S&T funds, and proposing, with relevant departments, major policies and measures for the rational allocation of S&T resources.
- Being responsible for appraising the National S&T Award, drawing plans for S&T talent team-building, and proposing policies.
- Drafting plans and policies on science popularization, the technology market, and S&T intermediaries, and being responsible for issuing confidential measures and managing S&T assessment and statistics.
- Drawing up policies on S&T cooperation and exchange through bilateral and multilateral channels, guiding relevant departments and local governments in international interaction, appointing and supervising S&T diplomats, and facilitating aid to and from China.[13]

2.2 Ministry of Education

Universities in China are playing an increasingly important role in R&D activities. In order to promote the translation of research for social and economic benefits, the HE sector must be engaged actively. The Ministry of Education (MoE) is the national organisation that oversees educational and research activities in universities in China. Specifically, the Department of Science and Technology under the MoE is responsible for guiding the transformation of research output in universities, development of high-tech industrialisation, collaboration of industries, universities and research institutions, and innovation in universities. In collaboration with MoST, the Ministry of National Defense, Ministry of Environmental Protection, and the Office of the Central Leading Group for Cyberspace Affairs, the department leads university participation in national S&T programs and projects. It also organises universities that participate in national technology innovation projects, implements the transformation of research achievements and high-tech industrialisation, develops the plan for high-tech industrialisation in universities, and manages university-based S&T parks. Another key responsibility of the department is copyright and intellectual property management in the HE sector.[14]

2.3 National Fund for Technology Transfer and Commercialization

In order to implement the *National Mid-Long-Term Science and Technology Development Framework*, accelerate the transformation and application of research achievements, and encourage nongovernment sectors and local governments to enforce the investment in research output transformation, the National Fund for Technology Transfer and Commercialization (NFTTC) was established in 2011. Its goal is to better play the leverage and guiding role in fiscal funding; exploit innovative approaches for fiscal investment in S&T; advocate for financial capital and private investment in the transfer of research output, and further develop a diversified, multi-level, multi-channel technology investment and financing system. Following the "introductory, indirect, non-profit and market-oriented" principles, the fund will be used primarily to support the transformation and utilisation of research output achieved in projects funded by fiscal investment, which include the national S&T programs, local S&T programs, and other new technologies, products, processes, materials, and equipment and systems generated by other public institutions.

Further, the fund will support the transfer of research achievements in a variety of ways, including the establishment of sub-funds for venture capital, loan risk compensation, and performance incentives. The sub-funds for venture capital will be co-sponsored jointly by the NFTTC and other qualified institutional investors to offer equity investments for enterprises that commit themselves to the transformation of research achievements. Risk compensation will be provided to cooperative banks that issue loans for research achievement transfer activities in compliance with the conditions and procedures. The NFTTC will also provide financial incentives to enterprises, research institutions, universities, and S&T agencies that make outstanding contributions to the transformation of research achievements.

Meanwhile, in accordance with the “overall planning, hierarchical management, open sharing, and dynamic adjustment” principles, MoST and the Ministry of Finance will establish a national project database for the transfer of research outputs. Except for those that involve national security, major social and public interests, and trade secrets, the summary information included in the database will be accessible to the public, and will provide a reference for venture capital institutions, banks, and participants from various sectors that cooperate with the NFTTC.[15]

2.4 Other agencies involved with the transformation of research achievements

In addition to the key national agencies mentioned above, a number of other agencies are involved with the transfer of research output, and provide various types of support. These include the Ministry of Finance, the National Development and Reform Commission, the Ministry of Industry and Information Technology, the Ministry of Agriculture, The People’s Bank of China, the State-owned Assets Supervision and Administration Commission of the State Council, the Chinese Academy of Sciences, the Chinese Academy of Engineering, the National Natural Science Foundation of China, the China Association for Science and Technology, and the State Administration of Science, Technology and Industry for National Defense, among others.

As the central government of China exercises jurisdiction over 22 provinces, five autonomous regions, four direct-controlled municipalities, and two self-governing special administrative regions (Hong Kong and Macau), various commissions and departments at the local level (e.g., the Department of Education and Department of Science and Technology) are responsible for developing their own specific policies for transferring research achievements that best accommodate the local context and conditions. Thus, they implement their own measures to facilitate research output transfer in order to contribute to local economic and social development. These policies and measures complement the national strategies.

3. National policy and legislation for the transformation of research achievements

In order to regulate and legislate the transformation of research achievements, China issued the *Law of the PRC on Promoting the Transformation of Scientific and Technological Achievements* in 1996. In 2015, a proposal was made to amend this law to better accommodate current needs and to further remove the barriers that impede the transformation. In addition, the State Council also issued the *Regulations for Transforming Scientific and Technological Achievements* in 1999.

3.1 The National Mid-Long-Term Science and Technology Development Framework (2006-2020)

This framework summarises the achievements that have been made in reforming the S&T system and building a national system of innovation in China. It also points out the weaknesses in current practices. Since the reform and opening up policy, reforms of the S&T system have been designed to integrate economic and S&T development and facilitate the transformation and industrialisation of research output. The reform has focused on the adjustment of structure and mechanisms by implementing a series of major reform measures, and has achieved important breakthroughs and substantial progress. Meanwhile, policymakers must be aware of the incompatibility between the current S&T system and the requirement of economic and S&T development. First, enterprises have yet to truly become the main body of technological innovation, because their independent innovation capability is not strong enough. Second, the separation and repetition of various S&T players results in ineffective operation of the whole. The field of social welfare, in particular, lags far behind in terms of innovation. Third, the management of S&T, the allocation of S&T resources, and the evaluation mechanism fail to accommodate the new situation and the requirements of government function transformation. Fourth, the incentive mechanism for innovation and entrepreneurship has not yet matured. All of these problems have restricted the nation's overall capacity for innovation seriously.

In order to eliminate these weaknesses and further promote the construction of a uniquely Chinese national innovation system, the framework suggests a series of measures, including:

- Taking the leading role in enterprises in the national innovation system and encouraging collaboration among industries, universities, and research institutes.
- Developing a knowledge innovation system that combines scientific research and higher education effectively.
- Developing a national defense innovation system that harmonises military and social development, and promotes the integration of civil and military technology and the transformation of research achievements related to national defense.
- Developing a regional innovation system with respective advantages and characteristics.
- Building a S&T service network and fostering all forms of S&T agencies, acknowledging the important role of universities, research institutes, and various associations as S&T agencies, and guiding the specialisation, scale development, and standardisation of these S&T agencies.
- Implementing preferential tax policies that encourage technological innovation in enterprises and the transfer of research achievements.
- Implementing the Law of the PRC on Promoting SME, supporting the establishment of small and medium enterprises of various natures, giving full scope to the vitality of technological innovation of SMEs, encouraging and supporting SMEs to adopt co-financing or co-commissioning and other means of cooperation in research and development, and providing policy advantages to accelerate the transformation of innovation achievements.
- Implementing financial policies that promote innovation and entrepreneurship, encourage financial institutions to support major national S&T industrialisation projects and projects for research output transfer, giving preferential credit support, establishing and improving the IP rights and credit guarantee systems to encourage innovation in small enterprises, and creating favorable conditions for SME financing.
- Accelerating high-tech industrialisation and the promotion of advanced technologies, enforcing the promotion of agricultural technology, establishing a new mechanism for the promotion of advanced and applicable technologies in rural areas, and establishing special funds for the transformation and promotion of agricultural research achievements.[16]

3.2 The National Mid-Long-Term Education Reform and Development Framework (2010-2020)

This framework emphasises the important role of universities in building the national innovation system and facilitating the transformation of research achievements.

Universities are important bases for fostering high-level innovative talent, one of the main forces in fundamental research and high-tech innovation, and a force that is vital in solving major scientific and national economic problems and transferring research achievements. The framework suggests that there is an urgent need to build a number of world-class research universities to meet the need to construct a national innovation system. A number of large, multidisciplinary universities have been established in China, and their role in S&T innovation must be exploited more effectively. The government should provide strong support to universities in order to achieve innovations in fundamental research, frontier research, social welfare, and other areas, and encourage collaboration among universities, enterprises, and research institutes in order to better serve national, regional, and industrial development. Universities are encouraged to establish their own bases for closer collaboration with industries and research institutes.

One of the key missions of universities is to build a S&T innovation platform and foster teams of internationally competitive academic leaders. Further reforms are needed in the management mechanism of universities, in order to optimize the academic system of education, S&T management, and innovation. Meanwhile, in order to provide better incentives for innovative talents, a scientific and reasonable evaluation system is necessary.

Community service and engagement is another key mission of today's universities. According to the framework, universities should establish firmly the need to serve the community, to enhance collaboration with enterprises and research institutions, to accelerate the transformation of research achievements, and to standardise the development of university-run industries. As a community member, universities should provide continuing education, promote the popularisation of science to improve public scientific and humanistic qualities, boost cultural communication, and encourage staff and students to engage in volunteer work.[17]

3.3 Law of the PRC on Promoting the Transformation of Scientific and Technological Achievements and Regulations for Transforming Scientific and Technological Achievements

In 1996, China issued the *Law of the PRC on Promoting the Transformation of Scientific and Technological Achievements* to promote the transformation of scientific and technological achievements into real production, standardise such transformation, hasten scientific and technological progress, and facilitate economic and social development. The law explicitly identifies the scope of "transformation [of] scientific and technological achievements," which includes the entire process, from follow-up tests, development, application, and widespread use of applicable scientific and technological achievements made as a result of scientific research and technological development, through to the final creation of new products, new techniques, new materials, and new industries—all for the purpose of enhancing production.

According to the law, the transformation of research achievements shall be instrumental in increasing economic and social benefits, and protecting the environment and natural resources, as well as strengthening national defense. In transferring research achievements, the person concerned shall abide by the principles of voluntariness, mutual benefit, fairness, and good faith in accordance with laws or contractual agreements. Intellectual property involved in the transformation shall be protected by law.

The administrative department for S&T, the planning department, the administrative department for comprehensive economic and trade affairs, and other relevant administrative departments under the State Council administer, guide, and coordinate efforts for the transformation of research achievements. Similarly, the local people's governments at various levels are responsible for doing the same within their respective administrative regions. The law consists of six chapters and 37 articles that regulate the implementation, safeguards, technological rights and interests, and legal liabilities of transformation of scientific and technological achievements.[18]

In 2015, a proposal was made to amend the law to serve the current situation more effectively. In the proposal, it was recommended that the original six chapters and 37 articles be modified to nine chapters and 58 articles. Specifically, Chapter 2 Implementation was divided into three separate chapters: "Research institutes and universities;" "Collaboration among industries, universities, and research institutes," and "Service for the transformation of scientific and technological achievements." The change emphasises the important role of HEIs in transferring research outputs. Another two new chapters concern "Scientific and Technological achievements funded by fiscal investment," and "Financial support." It was suggested that the original chapters on "Safeguards" and "Technological rights and interests" be combined into one chapter on "Safeguards and incentive measures."[19]

In order to encourage research institutes and universities to develop new technologies and to transfer research outputs, the State Council issued the *Regulations for Transforming Scientific and Technological Achievements* three years after the law was issued. There are three major parts to the regulation, including the encouragement of new technology development and research achievement transfer in research institutes and universities, the guarantee of the autonomy of high-tech enterprises in operation, and the creation of favorable environments for the transformation of high-tech.[20]

4. National Programme for promoting the transformation of research achievements

It is clear in the last section that the transformation of research achievements has been a policy and strategic priority in China, and a solid national policy and legislative framework has been established for the activities of research output transfer. The Chinese Government has invested substantially in, and established special national projects to promote the transformation of scientific and technological achievements, including the Spark Programme, Torch Programme, Science and Technology Programme of Wellbeing, and the Transformation Fund for Agricultural Science and Technology Achievements, among others. In this section, the administration, management, and measurement of these national programs will be introduced.

4.1 The Spark Programme

The Spark Programme is the State Council-approved policy-guiding program, which is designed to revitalise the rural economy and popularise S&T so that farmers can benefit financially from S&T innovation. It is an indispensible component of China's national economic and social development plan. It is also the first central government-approved plan to promote rural economic development through S&T that has been launched since 1985.

- **Purposes**: insisting on addressing agriculture, rural areas, and farmers; relying on technological and institutional innovations that promote strategic restructuring of agriculture and rural economies, and helping farmers benefit financially by promoting agricultural industrialisation, rural urbanisation, and an acceleration of the process of agricultural modernisation.
- **Missions**: to promote the adjustment of the rural industrial structure, to increase farmers' income, to promote the sustainable and healthy development of rural economies, to strengthen the popularisation of advanced and applicable technologies in rural areas, to hasten the transformation of research achievements, to popularise scientific knowledge, to create a favorable environment for S&T development in rural areas, to support the integration of advanced technologies in relation to agricultural product processing and the utilisation of agricultural resources and other rural industries with similar characteristics, and to improve productivity in rural areas in China.
- **Administration**: the administration of the Spark Programme is multi-level, and includes national, provincial, municipal, and county S&T departments. Under the MoST, the Spark Programme Office is responsible for the centralised management of the program. Provinces, autonomous regions, municipalities, and relevant ministries under the State Council are responsible for the application, implementation, and evaluation of Spark Programme projects in their respective regions.
- **Evaluation**: the Spark Programme Office or other authorised departments are responsible for the evaluation of key projects. The completed key projects are required to apply for evaluation within three months. For those projects that fail to meet the evaluation criteria, except in cases caused by uncontrollable factors, the Office will inform the public.[21]

In 2012, The Spark Programme funded 1473 national projects, including 129 key projects. Figure 5 shows the distribution of key projects in different fields.

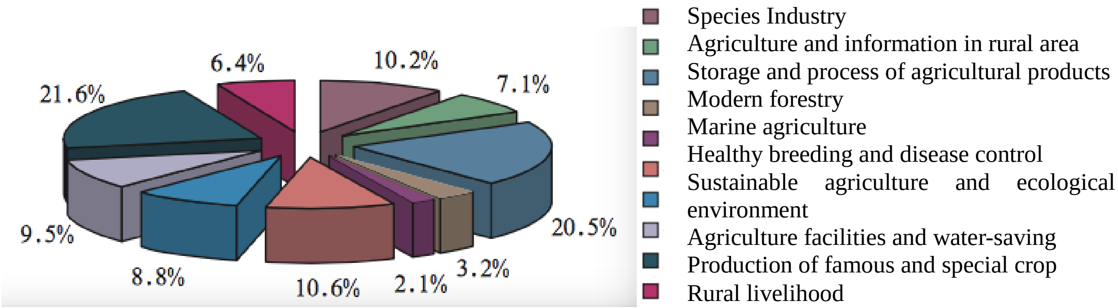

Figure 5: Distribution of key national project in different fields (2012)

Figure 6 presents the performers of all the national projects under the Spark Programme. It can be seen that enterprises play a leading role in the program.

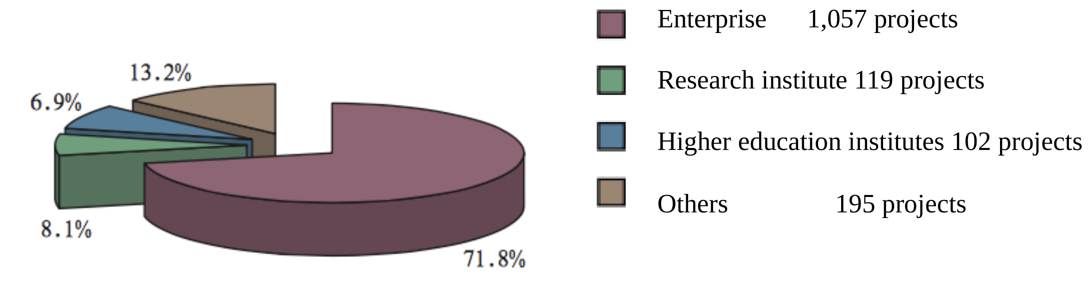

Figure 6: Distribution of national projects by performers

In 2012, the investment in key projects of the Spark Programme reached ￥200 million (approximately AUD40 million at the current exchange rate). Figure 7 shows the investment in different types of key projects.

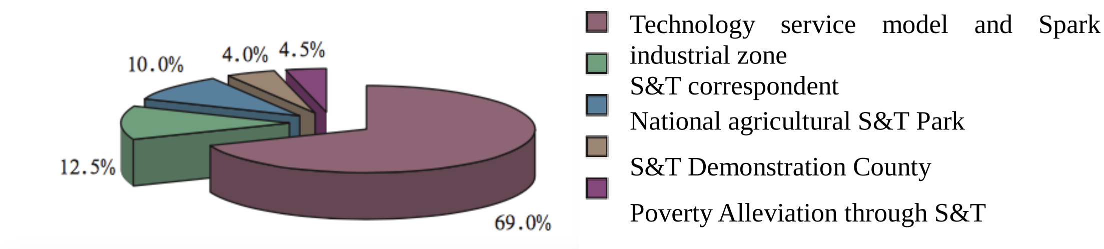

Figure 7: Investment on different types of key projects (2012)

In 2012, the main achievements of the Spark Programme included:

- New achievements were made in S&T innovation and building S&T service networks in rural areas. Specifically, the S&T agent and rural S&T start-ups promoted vigorously the construction of "a chain," "one stop," and "two bases" in rural areas. Universities played a leading role in establishing the research institute of new rural development, which has made substantial contributions to the acceleration of research output transfer, the improvement of S&T services in rural areas, and the employment and entrepreneurship of farmers. In 2012, a series of industrial chain projects was implemented, including 73 national S&T agent start-up chains. The number of service stations for S&T correspondents reached 5,000.

- The pilot for information-based rural areas progressed gradually. The focus was the establishment of information-based demonstrations for rural areas in different provinces, a distance education program on "S&T in rural areas" for civil servants in rural areas, the Spark S&T information service, and the TV program, "Spark S&T 30 minutes." All of these measures contributed to the establishment of comprehensive information service platforms in rural areas.
- The scientific quality and educational level of farmers has also progressed gradually. In 2012, the Spark S&T training was designed to benefit farmers and increase their income and it focused on "technology demonstration, base construction, talent development, and competence enhancement." In order to solve the problem of the low educational attainment of farmers, various S&T training projects were launched. Consequently, a group of practice talents and technology leaders was fostered in rural areas, which aroused farmers' enthusiasm for learning about S&T, improved their ability to use technology, and helped them increase their incomes.
- The Spark S&T training system improved steadily. This training took into account local conditions, and vigorously built Spark schools and training bases at all levels. A farmers' S&T education and training system has been established, within which the Spark training network is the leader, and agricultural enterprises and colleges, vocational technical schools, research institutes, and agricultural technology promotion agencies are the main force, supplemented by a variety of technical and economic organisations. The advantages of the training resources of the Spark school have been used effectively. A variety of S&T training programs were conducted, which combined both intensive and decentralised training, classroom learning, and on site guidance. Further, the S&T training provided farmers with the integrated use of radio, television, newspapers, websites, and other media.
- As of the end of 2012, a total of 5,745 Spark S&T training bases had been established, including 4,199 Spark training schools. The number of edited teaching materials reached 277,700, with 85.13 million published textbooks and 83,700 course PPTs.
- The construction of an industrial zone and base was facilitated. Based on the existing S&T demonstration areas, expert workstations, Spark technology dissemination stations, and research bases, the Spark industrial zone and S&T parks researched and developed applicable technologies and products, and established significant technology demonstration areas. The introduction of key technologies and the integration of management, capital, technology, and personnel contributed to the establishment of a platform for S&T talent, the application and demonstration of large-scale industrialised projects, the development of featured industries, and the construction of industrial zones.[22]

4.2 Science and Technology for Wellbeing Programme

In order to implement the National Mid-Long-Term Science and Technology Development Framework, to accelerate the transformation of research achievement, and to enhance the leading role of S&T in improving people's livelihoods and promoting social development, the MoST and the Ministry of Finance launched the Science and Technology for Wellbeing Programme. Relying on technological progress and mechanism innovation, the program is designed to facilitate the transformation of research achievements in the field of social development and enhance the ability to promote social management innovation and build grass roots-oriented social services through S&T. The scope of the program covers population health, environment, public safety, social management, and other fields closely related to social development. Its core missions include supporting the transformation and application of advanced research achievements, enhancing practicality and industrialisation, supporting the integration and demonstration of advanced applicable technologies in key areas, and promoting the transformation and application of advanced applicable technologies in the field of public service.

- **Guidelines:** the program is driven by the demand for technologies related to people's livelihoods, and is led by S&T innovation. The collaboration among industries, research institutes, and universities plays an important role in promoting the application of research achievements in benefiting people's lives and sustainable development. Adhering to the principle of diversification of funding sources, the central and local governments invest together to encourage and guide social capital and other diversified investments. The program is managed by central, provincial, and municipal governments. All of the relevant departments of S&T and finance are to coordinate with each other, promoting the program jointly with their respective responsibilities. This program is project-based and is implemented annually. It is important to standardise the procedure, to emphasize management according to set objectives, and to enhance effectiveness. Evaluation is a key phase in program management.
- **Administration:** The MoST is responsible for the general management of the program. Jointly with the Ministry of Finance, the MoST is responsible for developing the program plan, managing funding, implementation, and supervising and evaluating the projects. The Ministry of Finance is responsible for examining and approving the program budget. Other relevant departments at the central level are involved in project consulting and supervision, as well as facilitating the popularisation of research achievements and successful experiences in relation to their respective fields (industry). The Departments of S&T and Finance at the provincial and municipal levels are responsible for the organization, implementation, supervision, and evaluation of the projects conducted in their respective regions. It is also their responsibility to integrate S&T resources,

coordinate with the central government, guarantee funding, and popularise the achievements.

- **Evaluation:** after the project is completed, the local organisational units need to propose an application for acceptance to the responsible provincial department within one month, submitting a project summary report, user report, financial audit report, and other materials. The provincial department approves the financial audit of the project, and then organises an evaluation team that involves technical and management personnel, as well as users, to review the project through the acceptance materials, a site visit, meetings, and other procedures. As a result of this process, the project is either accepted or rejected. The accepted projects must complete the goals and tasks identified, and the funds should be used reasonably. A project is rejected for the following reasons, among others: it did not meet the main assessment criteria; fraud was involved in providing data and materials; there were disputes over the implementation and results of the project; the project was not completed after a six-month extension with no justification; or the funds were abused. For the projects rejected, the local organisation is responsible for supervising the rectification of the project and applying for reevaluation within three months. If the project is rejected again, the local organisation, the project undertaken by the organisation, and the responsible person will not be allowed to submit any more projects under the program for three years. To address some of these issues, the MoST and Ministry of Finance together have gradually established a performance evaluation system for the program. Within three years after projects are accepted, the MoST and Ministry of Finance conduct a joint comprehensive evaluation of the effects of the implementation, the use of funds, and the management of the project. For those projects with satisfactory evaluation results and advanced management experience, the MoST and Ministry of Finance will grant an award to the project and encourage the transformation of the project achievements. A sound information publication and credit management system has been established by the MoST and Ministry of Finance jointly. Through the system, the public can obtain access to the project information and achievements. This is an important element of accountability, and public supervision will contribute to the transformation and application of project achievements.[23]

4.3 The Torch Programme

The Torch Programme is an essential part of China's high-tech industry development plan. The program was approved by the Chinese government in 1988 and was implemented by the MoST. The Torch Programme is designed to develop the strength and potential of Chinese S&T and facilitate the commercialisation of high-tech achievements, the industrialisation of high-tech products, and the internationalisation of high-tech industries. To guide the policy, the Torch Programme has played a positive role in promoting the transformation of research achievements and accelerating the transformation of traditional industries. It enables the government to create an environment that helps knowledge and S&T talent enter the market as essential productive factors, and establish a corresponding mechanism. The program also creates an innovative environment for high-tech enterprises, which relies heavily on the integration of technologies, the upstream and downstream industry chain, and the innovation chain, so that high-tech enterprises have become an important part of China's S&T work. In the meantime, the program has been effective in promoting the development of regional economies and adjustments in the economic structure.

The Torch Programme is dedicated to in-depth research, the integration of S&T management resources, strengthening research on new models for research output transfer, the exploration and expansion of channels, and the establishment of a dynamic working system driven by the market and led by government. The core mission of the working system is to promote the transformation of S&T achievements, and the foundation is market evaluation of applicable technologies, as well as third-party market research and assessment. The system's goal is to make full use of the brand effect of S&T exhibition and gather a variety of resources for research output transfer and popularisation. The program emphasises optimising combinations of elements, sharing resources, accelerating the industrialisation of S&T achievements, and promoting regional technology upgrades, in order to achieve strategic innovation and development.

One of the main goals of the Torch Programme is to support enterprises' independent innovation. The program enables private enterprises to participate equally in competition for government-funded S&T projects, allows private technology companies to use stock options to encourage innovation and entrepreneurship among S&T talent, and in particular, promotes entrepreneurship and development of S&T enterprises by nurturing various business incubators. Private technology enterprises grow gradually in market competition and become an important force in developing the high-tech industry and building an innovative nation.

In terms of improving the capital market, the Torch Programme contributes to the multi-level capital market, and promotes the construction of an investment and financing system that provides solutions to the financing difficulties encountered by technology companies. For example, the SME Technology Innovation Fund approved by the State Council can help SMEs cope with the initial phases of innovation and development, thereby alleviating the difficulty of financing. Another example is the pilot counter for pit trading in national high-tech zones, which aids in the transformation of technological property. This measure solves the problem of financing encountered by small and medium sized technology companies and helps many enterprises grow and develop.

In addition, strengthening international cooperation and promoting the internationalisation of the high-tech industry is also an important part of the Torch Programme. In this regard, the program organises and implements the *Internationalising Trade and S&T Plan*. Led by the MoST and Ministry of Finance, and coordinated with the other seven ministries, the plan is designed to strengthen trade through S&T and improve the export of high-tech industries. The Torch Programme establishes cooperative relations with a wide range of countries and regions through both government and civil channels, and has founded a number of overseas business parks, such as the S&T industrial park in the US, Russia, and Singapore, and the APEC S&T industrial park. Through the exchange and cooperation with overseas S&T, finance, and business circles, the program enables Chinese high-tech products and high-tech enterprises to enter the international market.[24]

The key tasks of the Torch Programme include:

- **Building high-tech industrial development zones.** The development of high-tech industrial development zones is an important part of the Chinese government's key strategy to strengthen China's high-tech industries, adjust industrial structures, promote the transformation of traditional industries, and enhance international competitiveness. The number of existing state-level high-tech industrial development zones has reached 88 to date. Based on the intelligence and space resources, the high-tech industrial development zone relies on China's own S&T and economic strength to maximise the transformation of research achievements into productivity. Facing domestic and foreign markets, the high-tech industrial development zones have become places with fruitful industrialisation achievements, active private technology enterprises, an atmosphere of innovation and entrepreneurship, and close attention to financial resources.
- **Building technology business incubators.** Under the guidance of the Torch Programme, China's business incubators have developed rapidly. S&T business development is designed to promote the transfer of research output and foster

high-tech enterprises and entrepreneurs. They provide various necessary services for the development of S&T enterprises to facilitate the growth of S&T enterprises, SME in particular. S&T business development has become the basis for the commercialisation of high-tech achievements, a school for nurturing S&T entrepreneurs, and an important part of the high-tech industry support and service system. They contribute substantially to the rapid and efficient transformation of S&T resources into social productivity, to the cultivation of high-tech SMEs and entrepreneurs with independent intellectual property rights, to the development of the high-tech industry, the optimisation of industry structures, and the creation of new employment opportunities.

- **Building the national Torch Programme software industrial base**. The Chinese government has recognised that the software industry, as the core of the information industry, is an important strategic industry, and its development is related closely to the nation's economic development, social progress, and national security. In this context, since 1995, the MoST has built the national Torch Programme software industrial base, relying on local governments and the national high-tech development zone. The base goal is to concentrate regional advantage in the software industry and create the policy, working, and living environments necessary to accommodate the development of software enterprises, which are expected to promote software technology innovation, product development, business development, personnel training, and exporting.
- **Implementing projects under the Torch Programme**. The Torch Programme selects and organises high-tech projects with economic benefits and strong potential. Driven by domestic and international market demands, and relying on national, local, and industrial research plans and achievements, the goal of these projects is the development and industrialisation of high-tech products. High-tech enterprises will carry out projects under the program. Those enterprises that meet the requirements of technology maturity, market prospects, the existing industrial foundation, and other aspects are eligible to conduct projects under the Torch Programme. The MoST is responsible for the approval of projects, together with the accreditation of industry experts, and the implementation of these projects under the program contributes to the development of high-tech enterprises. The projects can be divided into two levels: national and local. The key fields funded include new materials, biotechnology, electronics and information, light mechanical and electrical integration, new energy, energy efficiency, and environmental protection.[25]

2,139 projects were funded by the Torch Programme in 2012, including 68 key projects. The distribution of the field of projects funded is presented in Figure 8. From the data, it is clear that projects in light mechanical and electrical integration, and new materials and application constituted the majority of all projects funded. Figure 9 shows the distribution of the 68 key projects funded in various areas.

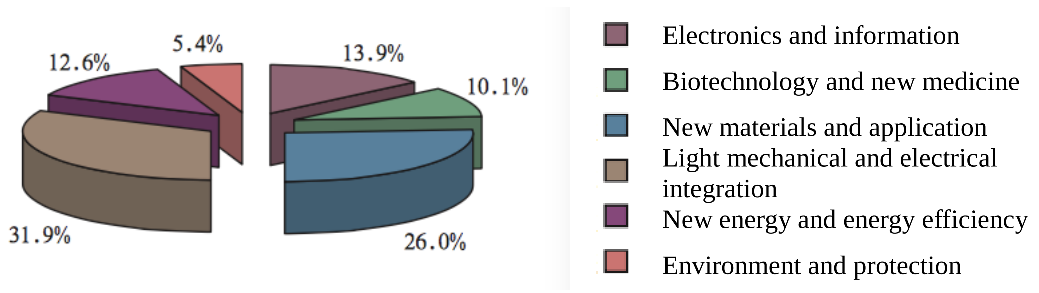

Figure 8: Field of projects funded by the Torch Programme (2012)

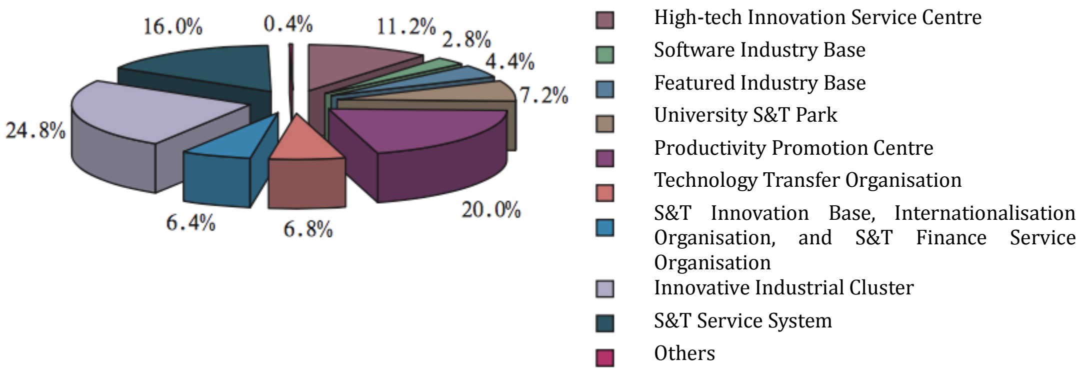

Figure 9: Areas of key projects funded by the Torch Programme (2012)

In 2012, the central government invested ￥220 million in the Torch Programme, of which ￥117.6 million went to key projects and ￥102.4 million to all other projects. The figure below presents the distribution of investment across different areas.

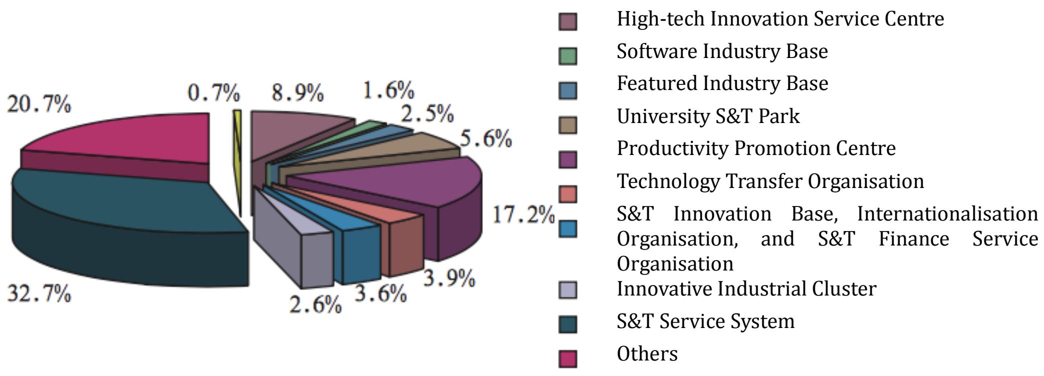

Figure 10: Distribution of investment on the Torch Programme projects by area (2012)

The main achievements of the Torch Programme in 2012 include:

- **Continuing to promote the management of the high-tech zone**. In 2012, 17 national high-tech zones were upgraded to national high-tech zones, and the number of national high-tech zones reached 105. The Torch Programme Office also approved the plan to build an innovative featured zone in 5 national high-tech zones.

- **Facilitating the construction of innovative industrial clusters**. The Torch Programme Office organised 41 pilot industrial clusters to participate in international communication and forums. A three-level system involving the MoST, and provincial and municipal S&T departments was established in 10 provinces to facilite further the construction of innovative industrial clusters.
- **Strengthening the management of the Torch Industrial Base.** In 2012, 6 National Torch Featured Indutrial Bases and 1 National Torch Software Industrial Base were approved. As a result, the number of these two types of industrial bases reached 290 and 39, respectively. The Torch Programme Office also reviewed and evaluated the existing 38 National Software Industrial Bases comprehensively, and provided evidence justifying the development of new software industrial bases.
- **Promoting the work of the Productivity Promotion Centre.** In 2012, 20 Productivity Promotion Centres were accredited by the Torch Programme, and the total number of national demonstration centres reached 256. In addition, 25 New Villiage Construction Service Centres, 19 S&T Financial Service Centres, and 63 Technology Tranfer Service Centres were accredited.
- **Promoting the innovative development of national university S&T parks.** University S&T parks play a leading role in promoting the transformation of research achievements, the cultivation of innnovative and entrepreneurial talent, and the development of regional economies. The Torch Programme Office organised the cooperation between university S&T parks, and local governments and enterprises to build platforms and transfer technology jointly, selecting 1000 projects that could be industrialised, securing 600 kinds of technology needs of enterprises, and signing 13 cooperation agreements.
- **Progressing in the development of the S&T business incubator.** The Torch Programme Office developed the *Twelfh Five-Year Development Plan for National S&T Business Incubator*, and amended the *Evalucation System for S&T Business Incubator*. It also reviewed and examined 346 national incubators, thereby strengthening their dynamic management. In order to improve the quality of the incubator management and service team, the office also organised training services for practitioners.
- **Strengthening and fostering high-tech enterprises.** By April 2012, the office completed filing for 22,221 enterprises in 122 batchs for the year 2011, and by November 2012, the office filed another 2,199 enterprises in 37 batchs.
- **Creating the environment for innovation and entrepreneurship.** By 2012, the number of national demonstration organisations for technology transfer reached 276, while the number of innovation stations reached 83. By the end of 2011, the demonstration organisation for technology transfer contributed the trading amount of ￥75 billion in technology. The “China Innovation Stations” visited enterprises 6,690 times, investigated the needs of those enterprises, integrated 8,814 pieces of shared innovation resources, organised 772 cooperations, and completed 876 service projects. Meanwhile, the Torch Programme promoted the combination of S&T and finance vigorously. According to the completed survey, various S&T

finacing service platforms had been established in more than 40 national high-tech zones, introducing more than 100 billion in venture captial and more than 1 trillion in bank loans. The financial investment exceeded ¥10 billion. The programme also strengthened the construction of the Torch international system, establishing long-term cooperation with relevant organisations in the UK, France, Korea, Russia, European Union, and Taiwan. The programme signed a MOU with the Korea Industrial Cluster Syndicalism, and the Russian Skolkovo Fundation. The programme office also organised several high profile international conferences, including the EU-China Innovation Cluster Conference, the International Conference for Building World-class High-tech Parks, and the 2012 Cross-strait Industrial Innovative Development Communication and Cooperation Conference. Jointly with the Ministry of Commerce, the programme office accredited 30 S&T innovation bases. The programme office also held a meeting for the Torch Internationalisation Alliance to promote resource sharing and cooperation among alliance members, including high-tech zones, incubators, technology transfer organisations, and productivity promotion centres. Currently, more than 40 members have joined the alliance, providing important support for the internationalisation of the Torch Programme. The nurturing of talent in high-tech industrialisation is also a major achievement of the Torch Programme. According to the interim statistics, over 51% of staff working in national high-tech zones held bachelor's degrees and higher, including 460,000 master's and 54,000 doctoral degrees, as well as 53,000 overseas returnees. This talent team has become the main force for national economic and social development. In 2012, the programme office organised 4 training projects for the MoST and achieved postive results.[26]

4.4 Blue Flame Programme

In order to respond to the international financial crisis and maintain rapid and stable economic development, the S&T Development Centre of the Ministry of Education launched the Blue Flame Programme in 2008. The programme is designed to promote the scope and depth of collaboration between HEIs and local government and organisations. The purpose of the programme is to enhance the supporting role of S&T in expanding domestic demands, maintaining growth, adjusting structure, benefiting people's livelihoods, enhancing regional capacity for independent innovation, and servicing local economic and social development. The first pilot cities involved in the programme included Zhangzhou in Fujian province, and Shangshu and Xixing in Jiangsu province, all of which were accredited in 2009.[27]

The core mission of the Blue Flame Programme is to facilitate targeted collaboration among HEIs and local governments, using the advantages of HEIs in talent and S&T and integrating regional economic and industrial characterisrics and needs closely.

The blue color symbolises S&T and the flame represents power. The programme is targeted to establish a technological innovation system that is market-oriented and collaborates with HEIs and industries. The programme encourages S&T practitioners in HEIs to go to enterprises, facilitating the comprehensive collaboration between HEIs and local SMEs and the integration of university S&T innovation with regional economic and industrial development. The programme is expected to accelerate the translation of research innovation in HEIs to social benefits, enhance the capability of S&T enterprises in innovation, and ultimately improve regional core economic competitiveness. Meanwhile, with the help of local and enterprise resources, sufficient funding could be provided to support HEIs, thus improving their research capability and the ability to service economic and social development. The programme will cooperate actively with central and local governments to promote the employment of university graduates and foster innovative and enterpreneurial talents.[28]

The main features of the Blue Flame Programme: 1) focus on pragmatism. Before the programme was implemented, the first task was to investigate the needs of local enterprises and the industry conditions. Taking these into account, cooperation plans can be proposed for collaboration between HEIs and industry, with a focus on such cooperative projects. The programme's goal is to promote in-depth communication among universities and enterprises, and universities and local governments, and 2) establish a long-term mechanism for collaboration between HEIs and industries. The programme will establish public R&D platforms for the transformation of research outputs in HEIs in the cities where the Blue Flame Programme is implemented, and will require local governments to provide special support. The platform will link univesities, local governments, and enterprises and will serve as the basis for long-term collaborations among universities and local organisations.[29]

The main objectives of the Blue Flame Programme: 1) the main short-term goal of the programe is to organise research staff to go to enterprises, understand the technical difficulties they encounter, communicate with them, promote the translation of universities' research outputs, and solve practical problems for enterprises; 2) as a joint endeavor on the part of government, HEIs, and enterprises, the mid-term goal is to establish a long-term mechanism for collaboration between HEIs and industries, and to introduce a market mechanism to build a policy conducive to the environment and operating system in order to transform research achievements. The programme also plans to build specialised and standardised large-scale technology transfer centres in universities, and foster a number of high quality S&T service teams, and 3) the long-term goal is to build a system for collaboration between HEIs and industries. The programme is designed to build a network and platform for collaboration between HEIs and industries, making technology transfer and the mobility of talent and knowledge between HEIs and enterprises operate more smoothly. Through these measures, the effectiveness of research output transfer will be improved and the collaboration between HEIs and entreprises will be tied closely. Universities will become an important force in providing key technology and industrial technology to the region.[30]

Pilot cities for the Blue Flame Programme: Taking into consideration the economic conditions, industry characteristics, and existing infrastructure, the S&T Development Centre of Ministry of Education selected three cities in 2009—Zhanghou, Chnagshu and Yixing—to pilot the programme. The pilot project will provide valuable lessons for improving the programme. In the pilot cities, following the steps of “understanding the needs, mutual communicating, and cooperating on projects,” the S&T Development Centre provides customised services in full consultation with the local government. After understanding the needs of the enterprises, the centre recommends these needs to relevant HEIs, and invites experts to research those needs. Meanwhile, depending upon the characteristics of the industrial development, the centre recommends the enterprises and local government researchers in universities with high-level capability in the specific field, thereby building a system of collaboration among government, industries, and HEIs. In the pilot cities, special attention has been paid to building a long-term mechanism of collaboration between industries and HEIs, establishing a Chinese university technology transfer centre and demonstration bases for featured technology transfer. The practice has shown that, through these initiatives, clear achievements have been made in the pilot cities that have benefitted local government, HEIs, and enterprises. Within just one year after the programme was piloted, the centre collected 260 types of enterprises’ needs and organised more than 600 experts from universities to visit those enterprises and meet approximately 800 enterprises' representatives, resulting in the establishment of 280 cooperation projects. In one of the pilot cities—Zhangzhou—the investment reached nearly ￥2 billion, and the China University Technology Transfer Centre Zhangzhou Branch was established with six featured technology transfer demonstration bases.[31]

Administration of the Blue Flame Programme: The programme is administrated jointly by the S&T Development Centre of the Ministry of Education and local governments. In the initial phase, the programme is open to those cities with featured economies and urgent needs for enterprise innovation. To determine the cities where the programme will be launched, the local government is required to provide information related to its level of economic development, industrial conditions, major enterprises, and technological needs, and to develop specific measures to promote collaboration between HEIs and industries. Once the plan is approved, the S&T Development Centre and the local government implement specific activites together.[32]

The procedure for launching the Blue Flame Programme: 1) the local government submits its report about local economic conditions, the features of local industries, and its development plan for the S&T industry; 2) the local government collects the technological needs of local enterprises and reports to the S&T Development Centre, which forwards those needs to relevant HEIs; 3) the local government and the centre establish a Blue Flame Programme Office jointly, which is responsible for developing the specific implementation plan; 4) the office recommends experts from universities who communicate with the enterprises, facilitate the transfer and application of research outputs, record the cooperative projects, identity key cooperative areas, and build local branches of university technology transfer centres; 5) according to the local needs, the office builds industry and research alliances and platforms for technology innovation, and introduces the S&T correspondent; 6) the local government develops supporting policies and incentives to promote the transformation of research achievements in HEIs, and 7) The Blue Flame Programme is launched officially.[33]

4.5 Other measures to promote the transformation of research achievements

In addition to the major national programmes mentioned above, other projects at the national level have been launched to support the translation of research achievements. One of these is the Agricultural S&T Achievements Transformation Fund, the goal of which is to facilitate the transfer of advanced S&T achievements with positive prospects, to promote innovation in agricultural S&T, and to establish an industrial chain. The fund is expected to support the healthy development of modern agriculture and related industries. In 2011, the central government invested￥500 million to fund 676 projects. The projects funded achieved substantial economic and social benefits. Those funded in 2008 generated accumulated sales revenues of ￥11.37 billion, among which US$156.23 million were foreign exchange earned from exports, ￥203.28 million were technical income, ￥2.62 billion were the total net profit, and ￥456.86 million were tax contributions. The projects funded in 2009 generated accumulated sales revenues of ￥29.67 billion, among which US$272.71 million were foreign exchange earned from exports, ￥179.79 million were technical income, ￥4.74 billion were the total net profit, and ￥1.31 billion were tax contributions. The projects funded in 2011 generated sales revenues of ￥41.03 billion, among which US$428.94 million were foreign exchange earned from exports, ￥383.07 million were technical income, ￥7.36 billion were the total net profit, and ￥1.77 billion were tax contributions.

In terms of social benefits, the projects funded in 2008 developed 267 new products, 192 new devices, 102 new materials, 667 new techniques, and 198 new technologies. These projects resulted in 304 patents and 1555 published papers. The funded projects also fostered 832 master’s and 260 doctoral degrees, and 62,882 training courses. As a result of these projects, 2,474 demonstration zones/bases were established, and 490,104 job opportunities were created. The 22 key projects funded in 2009 developed 77 new devices, 14 new materials, 29 new techniques, and 31 new technologies. These projects resulted in 79 patents and 103 published papers. The funded projects also resulted in 103 master’s and 28 doctoral degrees, and 1,992 training courses. As a result of these projects, 1,461 demonstration zones/bases were established and 6,643 job opportunities were created.[34]

In addition to the national programmes, various projects have been developed at the provincial and municipal levels to support the translation of research achievements, taking into account special local needs and conditions. The department of S&T and the bureau of finance at the local level usually cooperate to develop the policies and measures needed to promote research output transformation at the local level.

5. University policies and measures to facilitate the transformation of research output

In addition to the national and provincial programmes, various policies and measures have been issued at the university level and implemented to promote the transfer of research outputs. In Mainland China, there are more than 4,000 different types of HEIs, and each may develop different policies and measures to encourage such transformation. Therefore, in this report, one case of a key national university is provided to serve as an example.

Nankai University, located in Tianjin, was founded in 1919 and is a key multidisciplinary and research-oriented university directly under the jurisdiction of the Ministry of Education. It is considered to be among the comprehensive universities with the widest breadth of disciplines. It features a balance between the Humanities and Sciences, a solid foundation and a combination of application and creativity. The university has 21 academic colleges, as well as a Graduate School, School for Continuing Education, Advanced Vocational School, and a Modern Distance Education School, and offers programs in literature, history, philosophy, classics, management, law, science, engineering, agriculture, medicine, teaching, and art. Nankai University offers 79 undergraduate courses, 231 master’s programs, 172 doctoral programs, and has 29 post-doctoral research centres. The university also has 2 key national labs, 8 of the Ministry of Education, 1 of the Ministry of Science, 1 of the State Environmental Protection Bureau, 11 of Tianjin, 3 engineering centers of the Ministry of Education, 1 national engineering center, 9 national bases for basic science research and talent cultivation, 1 base for cultural quality education, and 6 key research bases for humanities and social sciences, together with 7 innovation bases in philosophy and social sciences, and 4 S&T innovation platforms. It has been included in both the 985 Project and the 211 Project.

Equipped with top academic capability and a creative spirit, Nankai University has a faculty well-balanced in age and specialties. Among the 2,041 academic staff, there are 632 doctoral supervisors, 741 professors, and 792 associate professors, 10 academicians of the Chinese Academy of Science and the Chinese Academy of Engineering, 5 academicians of the 3rd World Academy of Science, 10 members of the Subject Assessment Division, 12 Degree Appraisal Committees of the State Council, and 11 nationally accredited experts who have made outstanding academic contributions. Currently, the university has a total enrollment of 23,925 students, including 12,749 undergraduates, 7,964 master's candidates, 3,212 doctoral candidates, 1,048 foreign students, 5,779 part-time adult students, and 33,966 distance education program students.

As a key national university, Nankai takes active advantage of disciplines, technology, talent, and information to enhance the industrialisation and commercialisation of research outcomes that serve the national and local economies and social development. Some research institutes, such as the China APEC Institute and the School of Economic & Social Development have become the "Think Tanks" and "Talents Cradles" for central and local governments. According to the "national needs, the world first-class" principle, Nankai has implemented the strategy of "innovation driven development" comprehensively, and actively promotes the construction of all forms of collaborative innovation centers, setting up close cooperative relationships with a group of colleges and universities, enterprises, research institutes, and government departments.[35] In 2011, with support from the Tianjin Science and Technology Commission, a Technology Transfer Office was established in Nankai University. It is a university-level agent for promoting the transfer of research outputs, and is committed to serve local economic development. Its goal is to provide a platform for the mobility of S&T talent, the communication of S&T information, and local government investment in S&T. The office's core mission is to assist the university's students and teachers in becoming technology entrepreneurs.[36]

According to Mr. Cui, the Programme Manager of the Technology Transfer Office, in 2014, the university issued a series of policies to encourage teachers to leave their teaching positions, transfer their research outputs, and start businesses. The university has pledged to retain their positions for 5 years. He elaborated further that the main forms of research outputs transfer at universities have been based on the trade of patents, technology services, and consulting. However, Nankai University has explored new innovations in the transfer of research outputs. It established the Jingnan Research Institute jointly with the local government of Jingnan district. The district government provided ￥330 million in seed funds to develop the project. The government also provided a 90,000 square-meter industrial park in Beizhakou Town in Jingnan district, including office space and industrial plants. Nankai University provided a management team and intellectual capital, encouraging teachers to start businesses in the institute. The institute provides one-stop services for teachers, including the space for collective innovation, incubators, legal consulting, financial consulting, IP services, and business registration services. He described the institute as a baby-sitter to help teachers succeed in the commercialisation of their research achievements.

During the interview with the Programme Manager, he also explained other measures the university has adopted to promote the transformation. One example is a pilot program launched in the School of Chemistry. The program solves the problem of transfer of income redistribution, the position of engineering and technical staff, and the performance evaluation of transfer activities. Another example is the technology broker program. The university plans to launch this program in the second half of 2015 to build a bridge between the university and enterprises in order to communicate the need for technology. This program has been launched at the neighboring Tianjin University, and has achieved substantial results. Unlike Tianjin University, the strength of which is in engineering, Nankai has comprehensive disciplines, with specialised management and technical staff in each field. Therefore, the collaboration between Nankai and enterprises or governments is broader and encompasses various fields. Nankai has another advantage, which is its large number of alumni. The university's goal is to exert an influence on its alumni in different fields in order to create opportunities for collaboration. Further, Nankai's brand will ensure mutual trust and allow such cooperation to run smoothly. With respect to cultivating students' entrepreneurship, Nankai launched the Postgraduate Innovation Plan in 2012, and encouraged its undergraduates to participate in the National Student Innovation Training Plan. The university provides special staff to support students' innovative ideas and offers assistance for their participation in the national plan. Each year, the university selects hundreds of students' innovation projects and submits them to the Ministry of Education. In May 2015, the Student Entrepreneurial and Practice Base was established in Nankai to further facilitate the innovation and entrepreneurship of students.

6. Collaboration between industries, universities and research institutes

Universities/Research Institutes (RIs) and companies are the main actors in the national innovation system,[37] and knowledge is generated and diffused among these organizations. The knowledge transfer between universities/RIs and industry has wide effects on the development of the national innovation system.[38] Since the institution of economic reforms in 1979, China's strategies for enhancing indigenous research and innovation capacities have, in part, involved the promotion of university-based research and commercialisation, particularly for elite institutions to which the central government provides the most funding.[39] The initial results have been promising. Enterprises affiliated with universities and RIs were among the earliest non-government high-tech producers in the 1980s and 1990s. Some of the most successful high-tech firms, such as Lenovo and Founder, stemmed from such roots.[40] Encouraged by such successes, Chinese leaders hope to use the leverage gained from research universities to acquire innovation and technological capabilities in more industrial sectors. During the collaboration of universities/RIs and industries, partners in each sector benefitted from the intensified linkages. For universities and RIs, cooperation with companies can be thought of as a method to conduct user-oriented innovation, which will improve teaching, learning, and research in S&T-related

disciplinary areas. The universities have acquired a third mission, in addition to science teaching and learning, to be key agents in commercialising technology, because companies, universities, and RIs function as the intelligence source that offers professional human resources to develop companies and reduce their R&D costs.

Many research universities have developed closer links to industries through various forms of collaboration, including university-affiliated technology enterprises, technology transfer contracts, patent licensing, joint-authored publications and university science parks.[41] Among them, the university science parks and university-affiliated enterprises are the dominant forms of University-Industry Linkages (UILs). As incubators of university-affiliated enterprises and high-tech firms, university science parks in China play an important role in universities' social service function. Since 2011, 86 national university science parks have been established in China.[42] Science parks associated with universities are meant to be a main mechanism to link HE and science research with production and economic development—one of the key requirements of post-1978 HE and science policy reform.[43] Successful endeavors in science parks can help fund university operations and scientific research, and drive local economic development, as well as attract highly-skilled overseas Chinese back to the mainland. Other initiatives have also made great contributions to both universities/RIs' research capacity building and companies' innovation and enhanced competitiveness. Because such a large variety of collaborative programs have been implemented in different universities in China, they cannot be elaborated in this report. Here, one of the most successful cases of UILs, the Brainbridge Program, is provided to serve as an example.

The Brainbridge Program is operated by Royal Philips Electronics, which is famous for its open innovation strategy. Philips has cooperated with Chinese universities, such as Shanghai Jiaotong University, to set up joint laboratory and other projects as a prime aspect of the open innovation approach. In addition to the research collaboration in 2005, Philips signed a research and education agreement with Zhejiang University and the Technical University of Eindhoven (Netherlands), which is designed to foster a new culture of technical excellence through the creation of a "brain bridge" between universities and companies in different countries, and to support China's efforts to create high-quality, "home-grown" scientists and engineers that the country will need to sustain its growing economy. According to the MOU with its partners, the three parties will concentrate on research and education in the health sciences, information technology, and electronic engineering. The technology and science related to healthcare is the center of the cooperation. Philips supports the joint research projects among the three parties, and provides a research platform for exchange students in the program. Students will also be able to conduct part of their research at the Philips research laboratories in the Netherlands, Germany, and Asia. In addition, professors from the two universities conduct research projects granted by Philips that are consistent with Philip's strategic plans. The cooperation between Philips in China and at the Zhejiang University includes joint research projects, personnel exchanges, and cooperation between the science park of Zhejiang University and Philips' innovation campus in China.[44]

The Brainbridge Program is only one of the innumerable collaborations between universities/RIs and industries. Other cooperative programs may involve more than one university and develop extensive collaborations between HEIs and companies. Microsoft Joint Master Programs is another example. Microsoft China has cooperated with many Chinese universities to set up joint software programs. Microsoft designs university courses for these kinds. When a student joins such a program, s/he will participate in Microsoft projects and work at Microsoft for a semester or more. Many students sit for the Microsoft certificate exam, and excellent students remain to work at Microsoft after graduation.[45]

The strengthened collaboration between industries, universities, and RIs represents the co-development of HE policy and S&T policy. China is now crafting policies intended to encourage an environment conducive to indigenous innovation as a mechanism to move up the global production value chain, and HEIs have multiple roles to play in this newly emerging vision of China as a global player in cutting-edge scientific research and technology development, as well as the knowledge-economy, as both knowledge creators and knowledge communicators.

7. Conclusions

Although, as shown above, the Chinese government has invested substantially in promoting the translation of research into social and economic benefits, and a great number of national and provincial programs have been launched, there remain problems and difficulties in transferring S&T achievements in China. The administration system and management of research output transfer are multi-layered and the coordination among different departments can be inefficient and ineffective. These result in redundancy of projects and programs, and wasted capital and human resources. The incompatibility between the needs of the market and research fields is another problem that constrains the ability of research achievements to benefit social and economic development. Although the venues for research output transfer are diversified, in comparison with other advanced countries, such as the US and Germany, the transformation rate in China remains low and the industrialisation scale small.[46]

The fundamental cause of the problems in achieving S&T transfer can be attributed to the special economic mechanism. The planning economic mechanism has been implemented in China for over 30 years, since the PRC was founded. On the one hand, in the planning economy, national research institutions were the main force for R&D, and all of the S&T programs were organised and implemented by the central government. The administrative department developed the research plans and required research institutions to implement them. On the other hand, enterprises at that time were only responsible for completing the production mission required by the central government, regardless of the market needs. Enterprises performed almost no R&D activities, nor did they collaborate directly with research institutions. As a result, R&D and production activities were separated. After the adoption of the market-oriented economic mechanism, the Chinese government realised the problem of separation; however, reuniting R&D and production cannot be achieved within a short period.[47]

In order to eliminate the difficulties in transferring research achievements in China, the central government will continue to build the national innovation system with enterprises as the main force. It has been suggested that the nationally-funded innovation programs will focus on applied and experimental fields, and the evaluation criteria should be economic benefits rather than publications or other indicators of research. The government has also prioritised the innovation programs according to the needs of enterprises. The ultimate users are encouraged to be involved from the beginning of any innovation programs. The government also plans to provide special financial support to those projects that are based on customers' needs and are developed and carried out jointly by universities, research institutions, and enterprises. Another important step may be the establishment of a technology commercialisation system, the core of which is the establishment of a technology service system. Technology service is designed to provide professional services for all forms of innovation activities through the market mechanism, and transfer S&T elements into productivity through commercialised technology services. The collaboration between universities and industries is expected to encourage the establishment of more cooperative research institutions. The innovation centres based in universities and university-based science parks are expected to facilitate the commercialisation of technologies, while the active public IP policy is expected to promote the application and spread of public technologies in China.[48]

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