Research Report

Japan's Scientific Research System and

Its Enlightenment to the Reform of

Chinese Academy of Sciences

by

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I, HUANG Yi (Student ID 51216615) hereby declare that the contents of this Master's Thesis / Research Report are original and true, and have not been submitted at any other university or educational institution for the award of degree or diploma.

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Summary

The Chinese Academy of Sciences (CAS) is the strongest scientific research force in China, but problems such as duplication of management and overlapping of resources have brought negative impacts on scientific research. For this reason, the CAS is undertaking a series of reforms. By optimizing its policy and administrative structure, as well as its implementation capacity, the CAS is expected to be China's driving force for excellence in the national and global scientific field, and to provide steadfast support for economic development. After Japan recovered from WWII, its science and technology was quickly revived through certain implementation of policy and reform. This report intends to uncover the advantages of Japan's scientific research system, and to provide tentative suggestions for the reform of the CAS.

From January to March 2017, a literature review was conducted to acquire a general perception on Japan's advantages in scientific research from numerous journals and articles. In addition, reports from the CAS and related experts will be reviewed to analyze the problems concerning reform. In March 2017, the author returned to China and conducted interviews with the scientific researchers of CAS, and conversed with several senior scientists on their opinion of the problems and the reform. After returning to Beppu, the author conducted the same interview with several Japanese scientific researchers as well as people working in organizations such as the Japan Science and Technology Agency (JST).

As concluded from a literature review, the advantages of Japan’s scientific research system are: emphasis on technology innovation; emphasis on knowledge creation; emphasis on talent cultivation; emphasis on investment in science and technology; effective administrative structure; and effective form of research institute.

The problems that CAS face are: low research and development (R&D) investment; an imperfect science and technology project system; low social cognition of scientific researchers carrying out administrative duties; unnecessary competition and wasting of resources; and low industrialization and international exchange.

Tentative suggestions for the reform of CAS are: combine CAS with Ministry of Science and Technology (MOST); de-administration of research institutes; raise R&D investment especially in basic science and innovation; promote industrialization; improve the scientific projects system; and increase scientific researcher welfare.

Chapter 1: Introduction

1.1 Research background

Upon entering the 21st century, China has held an expeditious development in many aspects of society. Its influential power in economics has been recognized worldwide. "Made in China" has become, these days, a legible symbol in almost every country globally. Despite what China has accomplished in certain aspects such as economics, several problems remain unsolved. Development, in a narrow sense, "is the systematic use of scientific and technical knowledge to meet specific objectives or requirements" (Business Dictionary, 2016). On September 5, 1988, China's former leader Deng Xiaoping gave a famous speech that mentioned "Science and technology is the primary productive forces" (Deng Xiaoping, September 5, 1988). Since then, China began to attach great importance to science and technology research. Chinese Academy of Sciences (CAS) was established in 1949, and was described as "the linchpin of China's drive to explore and harness high technology and the natural sciences for the benefit of China and the world." The CAS comprises a comprehensive research and development network, a merit-based learned society, and a system of higher education, thus bringing together scientists and engineers from China and around the world to address both theoretical and applied problems, using world-class scientific and management approaches. The CAS comprises 104 research institutes, 12 branch academies, three universities, and 11 supporting organizations in 23 provincial-level areas throughout the country" (Chinese Academy of Sciences [CAS], 2017). When discussing China's science and technology research, CAS is used as a code word. During the past 28 years, Chinese scientific research has made important contributions to the world, for instance the Nobel Prize winner Tu Youyou discovered parasite therapies using artemisinin. However, Tu Youyou is known in China as a "three noes" winner: no medical degree, no doctorate, and no overseas working experience. Although people's first impression of a scientist is one that is from CAS, Tu Youyou is not. According to the Science Citation Index (SCI), one of the most authoritative indicators to evaluating the science and technology capacity of a country, China ranked 28 in the world 30 years ago, and became number 2 since 2010. However, worldwide, China's science and technology capacity is recognized to be lower than that of Japan's. Japan is the second-ranked country of all Nobel Prize winners. Up to 23 Japanese people have won a Nobel Prize during the past 67 years, including the latest winner Yoshinori Ohsumi, on October 3, 2016 (the first Japanese winner was Yukawa Hideki in 1949). Certain reasons must exist for such a prodigious achievement. Scientific research is never a single philosophy, it interacts with a complex integration of numerous aspects such as culture, economy, politics and geography.

This report focuses on science policies and administrative systems that impact scientific research. Some good policies have proven to be less efficacious because a thorough and irrational system has not been implemented. Due to the above-mentioned accomplishments, Japan's scientific research has become a good exemplar for CAS to study. Not only are Japan's policy, administrative system, and implementing ability good examples, but they are also a means to revealing the way people think as well. Currently, the CAS appears to have various problems in the field of scientific research. In China, science policies are formulated from a government perspective, which often fails to meet national demand, owing to a lack of profound cognition of science itself and adequate comprehensive research (Lu & Tang, 2014, p. 109). Government funding is granted to trending research fields that might not provide solutions or contribute to the furtherance of Chinese society (Zhou, 1998, p. 65-66). Additionally, government financial support for some projects arrives too late, thus scientists are required to use such support within a very limited period. Research institutes and universities can also reduplicate research fields, which is a source of huge financial squander as well as human resource waste. For example, in Beijing only, over five research institutions carry out research projects on superconductivity. Clearly, these institutes have to compete intensely to gain funding from the government. Many scientists spend almost two thirds of their time on applying for projects, and consequently do not spend sufficient time in the laboratory. Under such circumstances, China wastes tremendous resources on useless projects, which actually exerts a severe influence on sustainable development. Moreover, under such conditions, the CAS eagerly ponders conducting a reform in science policy and the administrative system, as well as implementation ability; the CAS is convinced such a reform will change their current predicament. Japan has found its own fame in scientific research, policy making, evaluation, capability of implementation, and even some national character; therefore, Japan is considered to be a good example for research and study for the reform of the CAS (CAS, 2017).

1.2 Research questions

What factors make Japan successful in scientific research?

What are the problems that the CAS faces in scientific research?

What can the CAS benefit from Japan for its reform?

1.3 Study significance

The CAS is the strongest scientific research power in China, but is facing difficult problems, such as overlapping projects, funding management, industrialization, and innovation (CAS, 2015). The Chinese government expects the CAS to be China's driving force for excellence in the national and global scientific field, and to provide strong support for economic development. This effort has required comprehensive restructuring to the Academy. By bringing a sharper focus and urgency, the initiative supports a new level of ambition in our day-to-day work and long-term mission. The initiative has the potential to make the academy stronger in both the basic and applied sciences that address specific national needs and challenges. At the same time, it strengthens CAS's role as a major hub for high-impact international research cooperation.

1.4 Research aim and expectation

The aim of this research is to study the science policy, administrative system, and implementing ability of Japan and to uncover what elements will be conducive to the reform of the CAS. Focus is applied to how the Japanese government and nongovernmental enterprises or organizations conspire together to promote scientific research. Additionally, data are collected from relevant institutes and scientists, interviews with government officials, then the data are analyzed and organized to arrive at a conclusion. The conclusion is expected to provide a rational train of thought that might provide a good suggestion in assisting the reform of the CAS, which to some extent will make its own contribution to the sustainable and harmonious development of China.

1.5 Methodology

This report focuses on differences in scientific research from the policy level to the individual level between Japan and China. Before coming to Japan, problems related to the above had been identified through observation and informal discussion with interrelated personnel at the CAS. With the support of these people, a literature review was conducted through various sources and individuals, which served as the concrete content of this report.

This study used qualitative methods in presenting findings by using a case study, interview, comparative study, and literature review methodologies. The phrase "qualitative methodology" refers in the broadest sense to research that produces descriptive data, i.e., people's own written or spoken words and observable behavior (Sun Y. 2013, p. 102). It is a way of approaching the empirical world. Qualitative researchers are concerned with the meaning people attach to things in their lives. Central to the phenomenological perspective and hence qualitative research is understanding people from their own frames of reference and experiencing reality as they experience it. Qualitative researchers empathize and identify with the people they study in order to understand how those people view things (Corbin & Strauss, 1998). This research focuses on three main questions:

What factors make Japan successful in scientific research?

What problems does the CAS face in scientific research?

What can the CAS benefit from Japan for its reform?

The researcher began the study with only vaguely formulated research questions, knowing less about what to study as well as what specific aspects to focus on until interviews and discussions were conducted. In February 2017, the author returned to China for 1 month to collect data, conduct interviews and conduct a case study.

Primary data were obtained from interviews and discussions with scientific researchers working in CAS institutes in Shanghai and Beijing. An anonymous questionnaire was used in the interview, focusing on several issues closely related to the research questions. Scientific researchers from different institutes, research fields, positions, and sexes were selected to conduct the interview. The questionnaire contents reduced preconceptions and the interviewees were informed that this questionnaire would only be used for the purposes of the current research, particularly to ensure their answers were relatively objective and genuine. In total, 15 researcher assistants, 10 assistant researchers, five associate researchers and two researchers were interviewed on their perspective of the problems they faced in their scientific research, together with suggestions for reform. At the headquarters of the CAS in Beijing, one division chief and one deputy director-general were interviewed about the reform of the CAS. The same questions were asked on the Japanese side: five assistant researchers, three researchers, and two senior consultants from the JST.

Secondary data were derived from the Division of Asia and Africa, Bureau of International collaboration of CAS in Beijing. According to the CAS annual report, 50% of the science collaboration conducted by the CAS in Asia was with Japan. The Division of Asia and Africa kept numerous data such as reports, journals, meeting minutes, interviews, annual reports, and collaborators' materials from the past 60 years. The researcher used to work at the division for over 2 years and was granted access to these data and records. On the Japanese side, relevant data were acquired from science and technology agencies, such as NEDO, JST, and JSPS. Furthermore, journals, articles, government white papers, and reports were also used to collect data.

Chapter 2: Literature Review

2.1 Introduction – Japan's advantages in science and technology

S. Liu (2005) stated that Japan is a country that attaches great importance to technological innovation. Over the years, Japan has adhered to the principle of "technological founding" and "technology legislation", making Japan a great power of technological innovation. In the 1960s, Japan had spent 6 billion US dollars to introduce over 25,777 technologies from abroad, among which 80% were patented technology. Furthermore, the digestion and secondary development after the introduction of these new technologies was the foundation of the so-called "technology founding" policy (p. 27). After the introduction of technology, led by the Ministry of Economy, Trade and Industry, Japan launched economic restructuring, with the government focused on supporting large enterprises for the national large-scale technological transformation, and formed its own unique industrial technology system. In technological innovation, Japan is good at improving original technologies, thus putting itself at an advantage in applied technology, civil technology research, and other related aspects. Although emphasizing too much on introducing technologies has its limitations, its basic role in enhancing industrial technology competitiveness was important. When the bubble economy burst, the Japanese industry showed strong competitiveness in developing new technologies and new products as well as expanding to new markets. Except for home appliances, Japan's manufacturing industry, including machine tools, industrial robots, semiconductor devices, lithium batteries, liquid crystal displays, and CD-ROM drives, still leads the world market. Japan's automobile annual output is more than 10 million, ranking first in the world. The Japanese automotive industry has not only successfully maintained the world's first-class production level and quality level, but its eco-car development is also far ahead of that of other countries'. The appliance industry, a traditionally Japanese strength, is also currently under a profound change in the connotation of renewable, information, and intelligent home appliances. In 2000, Japan Advanced Institute of Science and Technology evaluated the technical competitiveness of 14 industries and fields in Japan (Japan Trade Promotion Council [JTPC], 2003, p. 81). The 14 industries and fields included new materials, household appliances, information products, communication systems and products, biology, energy, electronic optics materials, microelectronics, medical technology, environment, system software, transportation and construction, production technology, operations, and talent. The results show that the overall competitiveness of Japan's technology is lower than that of the United States, but higher than that of Europe. Technical competitiveness is lower than the United States in industries related to biology, system software, communication systems and products, medical technology, business strategy, and management personnel; while the industry that remains on par with the United States is microelectronics. Industries with technical competitiveness slightly higher than that of the United

States are new materials, electronic optical materials, information systems and products, energy, environment, transportation, and construction; while the industry that is much higher than that of the United States is home appliances. Industries and technical competitiveness lower than that of Europe are biology, medical technology, and business and talent; while industries at the same level as that of Europe are system software, environment, and communication systems and products. Industries that are slightly higher than that of Europe are energy, and transportation and construction; the other six areas are much higher than that of Europe (JTPC, 2003, p. 82, 87).

In the field of basic research and high technologies in recent years, Japan has strengthened research on capital and policy support, formulated the "National Industrial Technology Strategy", and created plans to encourage the integration of industries and universities in research to improve the ability of technological innovation and to strengthen basic research, thus achieving initial results. In 2002, Koichi Tanaka from Shimadzu Kyoto won the Nobel Prize. From 1981 to 2000, the number of papers Japan published in the world's major scientific journals was just second to the United States, accounting for 10.1% of the total number of papers (Liberation Daily, 2002). In the fields of information technology, bio-engineering, new materials, and other high technologies, Japan claimed several discoveries and inventions. For instance, in the field of neutrino research, Professor Sugawara Takao from the University of Hawaii proposed destroying nuclear weapons with neutrino-beam bombardment. The superconducting magnetic levitation train with a top speed of 580 km/h was world-record breaking. Furthermore, as S. Liu claimed, Japan’s semiconductor technology was 5 years ahead that of the United States (2005).

2.2 Characteristics of Japanese science and technology policy

S. Liu (2005) noted that Japan's national innovation system was changing from a reverse national innovation system to a positive national innovation system (p. 27). In a narrow sense, it mainly refers to the scientific and technological innovation system, which includes both research and development and the mechanism of transferring technology to real productivity, processes, and methods. Broadly speaking, it also includes related system innovation. Yang (2005) noted so far, the development of the Japanese national innovation system could be divided into three stages or three types:

a. Use industrial applications to promote relevant technology research and development of a reverse national innovation system, or a national technology innovation system. This type began during the WWII and was developed in Europe and the United States during the 20th century for 40–70 years, which was the typical industrial economy era of the national innovation system. Its characteristics are influenced by the theory of technological progress, emphasizing technological innovation, technology flow, interaction of actors, and policy innovation (p. 30).

b. Use science and technology research to promote industrial development or even a breakthrough in the national innovation system. In 1980–1990, developed countries transferred from the era of industrial economy to the era of knowledge economy after the post-industrial era of the national innovation system, under the influence of endogenous human resources theory and new growth theory. In addition to continued focus on technological innovation, the production, dissemination and application of knowledge and its role in the economy were emphasized. New knowledge, new technology, key knowledge diffusion, personnel mobility, and innovation indicators were also valued (p. 31).

c. Knowledge-centered, two-way linkage of the national knowledge innovation system. Its embryonic form in developed countries has just begun to appear, which belongs to the era of knowledge economy in the national innovation system. In emphasizing the efficient application of knowledge innovation and knowledge, its theoretical basis is knowledge innovation theory and knowledge growth theory (p. 32-33).

The reverse of the national technological innovation system made significant contributions to the 20th century, including the economic miracle from 1960 to 1980 in Japan and South Korea and other East Asian countries and regions. The positive national innovation system was a powerful driving force in the 90's US national economic prosperity (p. 34). With the transfer of the world economy to knowledge economy, the positive innovation system of knowledge and technology has become the unanimous choice of developed countries. The development of reverse development and increased attention to technological innovation is a major feature of the Japanese national innovation system; however, after experiencing the painful economic crisis in the 1990s, Japan began to make adjustments for the policy of the positive national innovation system.

2.3 Concerning people’s livelihood and environmental protection

Zheng, Guan, and Chen (2013) concluded that in 2007, the "Innovation 25 Strategy" put forward the urgent need to deal with the problems of a rapidly aging population and a rapidly decreasing infant birth rate. Furthermore, to accelerate the development of knowledge and intellectual competition, knowledge society, information society, and globalization will become the mainstream of international competition. Environmental degradation, weather anomalies, energy shortages, and spread of infectious diseases threaten the normal operation of the Earth. To this end, Japan has formulated the goal of developing people's livelihood technology, i.e., creating new value through science and technology and services, promoting productivity, promoting sustained economic growth, and promoting win-win environmental protection (p. 108-110).

2.4 Encouraging the integration of Industry-Government-Academia

Chang (2009) noted that "Innovation" is the source of the development of the Japanese national economy, and that the government ensured science and technology policy were located at the starting point to improve their innovation capacity, revitalize education, cultivate comprehensive and innovative talents, and to promote the integration of "Industry-Government-Academy" (IGA). As the main promoter of the IGA, the Japanese government has provided a series of policy guarantees and a development environment for promoting the cooperation of the three parties, and promoted the diversification of the subject of science and technology policy activities (p. 58).

2.5 Focusing on knowledge creation

Attention to knowledge creation is one of the main features of Japan's science and technology policy in recent years. The so-called knowledge creation bases its center on the enterprise, university, and government research institutions, while giving full play to personal intelligence and creativity, and promoting knowledge innovation, invention, and creation (Zheng, Guan and Chen, 2009, p. 46). In the second "Basic Science and Technology Program", Japan established the "science and technology to create founding" strategic objectives by setting knowledge creation as the basic direction of science and technology policy.

According to Xu (2011), specific provisions included: 1, through the flexible use of knowledge innovation, become a country useful to the world --- the creation of new knowledge; 2, become a country with international competitiveness and sustainable development --- create vitality based on knowledge; 3, establish a country with peace and contentment --- build a wealthy society with knowledge (p. 83-85). To effectively protect knowledge creation, in recent years, the Japanese government stepped up the development and implementation of the "intellectual property strategy" and moved forward its relations with "intellectual property legislation" countries. In October 2001 the "Industrial Competitiveness and Intellectual Property Research Society" was held. In March 2002, the "Intellectual Property Strategy Conference" was held, and in July of the same year, the "Intellectual Property Strategy Outline" was promulgated. By November 2002, the "Basic Law on Intellectual Property Law" was passed at the 155th Congress. In March 2003, the "Intellectual Property Strategy Division" was established and in July of the same year, the "Intellectual Property Promotion Plan" was established. Xu (2011) noted four main aspects to the strategy of intellectual property rights in Japan: to promote the creation of intellectual property rights of universities and enterprises; to strengthen the protection of intellectual property rights; to promote the use of intellectual property rights; and to attach importance to the training of intellectual property related personnel (p. 85-87). In the past, Japan's theory and practice had a misunderstanding that intellectual property is a private right, and its protection relied on the patent holder's self-protection. Therefore, for a long time, administrative power was not generally involved in intellectual property rights. With the implementation of an intellectual property strategy, the Japanese government began to use administrative guidance, administrative contracts and other efficient, fast and flexible administrative powers to become actively involved in the creation of intellectual property rights, protection, and utilization. Activities included the establishment of a convenient patent review system, and the implementation of international standards for patent examination. The judiciary also began to intervene in investigating and handling intellectual property rights. This included strengthening the "patent corps" construction, reforming the judicial system, expanding the ranks of judges, and improving the efficiency and transparency of the trial (Liu, 2005, p. 27-29).

2.6 Implementing the strategy of science and technology talent

The importance of human resource development in the new century is far more than that of developing material resources (Zheng, Guan and Chen, 2009, p. 46). The implementation of scientific and technological talent strategy has become one of the main features of Japan's science and technology policy in recent years. Under the new situation, Japan first set a new concept of science and technology talent. In 2003, the "Science and Technology White Book" proposed the Japanese science and technology talent "concept map". It clearly highlighted that scientific talent from five files would be cultivated and attracted: 1, professional and technical personnel; 2, business management personnel; 3, scientific and technological socialization personnel; 4, science and technology popularization personnel; and 5, skilled personnel (MEXT, 2004). According to the concept map, a wide range of scientific and technical personnel included at least researchers, research support staff, technical personnel, research and evaluation personnel, management personnel, identification of qualified personnel, intellectual property related personnel, and business support staff. For the implementation of scientific and technological talent strategy, according to Gao (2004), Japan adopted a series of policy measures: (1) The establishment of a talent growth mechanism, such as widespread popularity of tenure, strengthening the flow of talent, attention to the cultivation of young researchers, pioneering talent, and a diversified development path. At the beginning of 2003, 29 national research institutions with 585 researchers, and 3546 faculty members at 65 national universities worked on a fixed-term basis. (2) Strengthen the training of innovative talents, such as reforming the education system; promoting the construction of universities, especially graduate schools; cultivating the economic and social needs of science and technology talent; and attracting overseas outstanding foreign scientific and technological personnel. By 2003, 531 out of 686 national, public, and private universities established a graduate school, and the total number of graduate students was 23 million. (3) Promote the adjustment of talent structure by actively enriching the team of researchers; expanding the ratio of female researchers; and emphasizing the development of old talent. From 2000 to 2002, although the number of in-service researchers in Japan decreased by nearly 50,000 people, the proportion of researchers increased by 3.3%. Conversely, the share of research support staff, technical staff, and researchers decreased by 1.2%, 1.4%, and 0.6%, respectively (p. 61-66).

2.7 Guaranteeing technology investment

In 1995, Japan developed the "Basic Law of Science and Technology", and from 1996 to 2000 the "first science and technology basic plan" was carried out. In those 5 years, the Japanese government's investment in science and technology was approximately 17.6 trillion yen, with the purpose of achieving its technology investment plan. From 2001 to 2005, the "second science and technology basic plan" was carried out. According to Qiu and Li (2007), during this period, the government planned to invest 40% more to science and technology than during the first phase; the total figure was approximately 25 trillion yen. The year 2003 marked the third year of the second basic science and technology program, and the Japanese government’s budget expenditure was increased by 0.1% more than that of the year 2002, while the technology budget had increased by 1.3% and reached 359.16 billion yen. Among these budgets, the amount allocated for science and technology actually increased by 3.9% over the previous year. The Japanese government's investment in science and technology accounted for only

21% of its total research fees, while the rest were form enterprises. Japan's research funding in 2002 amounted to 16.5 trillion yen, accounting for 3.3% of its gross domestic product (GDP), which was the highest among developed countries. To create a new industry development space, Japan invested 305 million US dollars in technology from 2003 to 2007 to develop robots for use in productive and medical welfare institutions. It was noteworthy that Japan had made a substantial return on its huge investment in scientific research (p. 80-87). With the efforts of the Japanese business community, technical decline was reversed, and a new industry took shape. Several new industries, such as the life science industry, environmental protection industry, and new nanomaterials industry were basically formed. The JIPDEC in 2004 noted that the Japanese government predicted, by 2010, Japan's life science industry market size would reach 25 trillion yen, and the environmental industry market size would reach 35 trillion yen (p. 1-3). To shorten its gap in relation to the United States in the information industry, Japan put forward the e-Japan plan, and accelerated nationwide media network construction. Japan planned to establish a wide-area multimedia network in 1/3 of all counties, cities, towns, and villages by 2005, ultimately covering the entire country by 2010 (p. 11). At that time, the administrative services, shopping, education, medical, and disaster prevention could be carried out through this wide-area multimedia network; thus, Japan's information industry would leap to the forefront of the world. According to government reports, the above-mentioned targets were all achieved. Some targets were even ahead of schedule, which proved the feasibility of these policies.

Chapter 3: Japan’s reform on its scientific research system

3.1 Introduction

In China, there is a saying, ‘taking history as a mirror, one can see how things rise and fall’. Both China and Japan severely suffered from World War II. Culture, economy, environment, resources, and science were almost ruined during that period. Post-war reconstruction was initiated during the same time, but the achievements differed in many aspects. By analyzing the history of scientific research development in Japan, and the reform of its scientific research system, a number of factors might be revealed.

Liu (2015) noted, after World War II, to restore the destruction of Japan’s scientific and technological resources, the Japanese government decided to develop a "foreign advanced technology" strategic approach (p. 28). In 1950, the Foreign Investment Law and the Foreign Investment Committee Establishment Law were enacted. The strong implementation of this policy enabled Japan to reach out to the world in the shortest possible time and to use the world's advanced technology and scientific research results, which shortened the technology development cycle, saved R&D capital, achieved revitalization of the economy, and narrowed its gap in relation to other developed countries. In years 1949 to 1970, Japan spent 57 billion US dollars in achieving technology introduced from abroad that had an actual value of 180–200 billion US dollars. By 1956, the Japanese economy had returned to pre-World War II levels. After the introduction of technology in the 1950s, Japanese technology maintained a certain material and technical basis to comply with the new development trend, and Japan developed a plan to "speed up independent technology research and development, and adopt efforts to narrow the technological gap" of the new technology policy (p. 28-29). The 1956 "Economic White Paper" put forward the idea of technological innovation as a new impetus to promote economic development; the 1958 "Science and Technology White Paper" intended to further develop a new direction for the development of science and technology, i.e., away from reliance upon foreign technology and towards independent development. The 1960 "national income multiplier plan" and the 1966 "Economic and Social Development Plan" stressed "independent technology research and development". Driven by the new technology policies, such as the implementation of a large industrial technology research and development system in 1966, the national major technology R&D obtained subsidies. To strengthen the pilot study of the tax credit system in 1967, the Japanese government guided the industry to establish their own innovation system and accelerated the formation of strong independent R&D capabilities. In the 1980s, Japan formulated the Outlook for

Trade and Industry Policy in the 1980s, the Law on the Implementation of Basic Technology Research, the Law on the Promotion of the Development of Higher Technical Industries, the Outline of Science and Technology Policy, "creative science and technology to promote the system", and a series of policies and regulations. In these series of intensive policy implementations, Japan, with the fastest speed and the lowest cost compared with other countries, caught up with Europe, the United States, and other advanced countries, especially in the steel, automobile, household appliances fields, and other fields as the world leader (Yang, 2005, p. 30-34).

In November 1995, the Japanese Congress unanimously adopted the Basic Law on Science and Technology, which was once called the Mirage Act. According to Xu (2011), it opened the prelude to the re-establishment of the Japanese science and technology system for half a century. Subsequently, the fundamental reform of the scientific and technological system was carried out in accordance with this law, which included the basic plans of science and technology and the implementation of the first phase (1996–2000) and the second phase (2001–2005) of policy, scientific research institutions and systems, and other aspects of the implementation in a series of major changes (p. 86-87). This had, not only a significant and far-reaching impact on Japan's science and technology, education, and other related fields, but it also shocked the entire international science and technology sector. Some regarded the reform as "the third most important change" in Japanese science and technology history—as important as the establishment of Japan’s modern science and technology system and the Meiji Restoration. Japan has always been regarded as a model of technological founding; especially since the end of World War II, Japan’s technology-based and -oriented economic construction and development achievements received worldwide attention. However, why did Japan carry out a major reform of its science and technology system during the mid-1990s? What were the motivations and goals of the reform? What were the conditions and initiatives of the reform? What were the supporting policies and means? These factors are analyzed, and used as a reference for the CAS to further deepen their reform in the near future.

3.2 Reconstructing science and technology

From "World War II" to the 1980s, the Japanese economy created a world-renowned high-speed growth "miracle." Experienced more than 20 years after the war and through hard work, in 1968, Japan's GDP reached for the first time more than that of then West Germany. Japan effectively jumped into the position of the world's second largest economic power. By the end of the 1980s, Japan’s GDP was only second to the United States worldwide. Yang (2004) noted that among the many explanations of Japan's "economic miracle", one of the most frequently mentioned factors is the so-called "late-developing advantage". This "late-developing advantage" meant that Japan’s economy grew through the introduction, absorption, digestion, utilization and development of existing technology in other developed countries rather than through autonomous development and focus on the realization of technological industrialization (p. 65).

3.3 The end of "technology introducing" and the responsibility of economic power

It is undeniable that Japan's post-war science and technology system and policy over a very long period of time was undoubtedly a success. But Japan still carried out a fundamental reform in the science and technology system. According to a study of Japan's history of science and technology policy, Japan's "foreign technology introduction" period was from 1945 to 1959. Japan's investment in the purchase of foreign patents in 1951 was more than 2.4 billion yen, and surged to nearly 22.3 billion yen by 1959. Enterprises were the mainstay of the introduction of technology in Japan, with the purpose of market-orientation and cultivating an independent innovation capacity. The introduction of the process was not a simple introduction of technology, but the introduction of technology and absorption, digestion and improvement. In the 1960s, the process of introducing the technical capacity of growth and the implementation of an open economic system brought about a certain degree of liberalization, and Japan gradually moved to "the establishment of independent technology" period with the goal of increasing international competitiveness. During this period, although the number of introduced technologies continued to grow, domestic scientific research investment increased significantly; in 1969 the figure was five times larger than that in 1960, and the proportion in total national income also reached 1.9%. In terms of technology trade, Japan's technology transfer funding continued to decline, reaching 10% in 1971. Meanwhile, technology exports raised year by year, and the ratio of technology exports income to introduction cost of technology rose to 1:8 in 1971. With the continuous innovation of Japanese technology capacity in 1970s–80s, Japan had transferred from introducing technology to independent technology development. In particular, Japan developed its technological advantages in manufacturing, health, energy development, environment protection, and other fields, which not only greatly improved the life quality of the people, but also strengthened its economic power to continue its growing influence in the international community. In 1986, Japan's GDP accounted for 11.9% of the world's total, and with foreign assets at 18 billion US dollars, it became the world's largest creditor. Although science and technology played an important role in Japan's economic growth, Japan had long neglected basic research and was only interested in scientific and technological activities for commercial purposes. Its investment in science and technology was based on industry rather than government. This noteworthy feature is the main difference between Japan's post-war science and technology policies and institutions and those of other developed countries; it was also one of the reasons why it had been widely criticized by the international community (Yang, 2004, p. 66).

With Japan's economic strength increasing, economic development crisis factors also increased. Since the late 1980s, Japan's economic power and the world's rapid technological advances constituted a serious challenge in its technology policies and systems. The trade friction between Japan and the United States and other Western countries increasingly deepened, while other developed countries required Japan to open up the market in the economic field to change the international trade imbalance. At the same time, in the science and technology field, being the most important basic factor for economic development, the international community held a higher expectation for Japan. It asked Japan to recognize the important responsibility of developed countries for the development of science and technology, and scientific research, especially for the development of basic research such as the international community's public wealth. Under that situation, Japan as a power strait, changed its science and technology development, and was ready to make a contribution to the progress of mankind.

3.4 The necessity of the reform and the "science and technology innovation founding" era

After 40 years of sustained economic growth, in the late 1980s, the Japanese economy began to enter a downturn in the "Heisei Recession" period, the so-called "industry hollow", and other deep-seated structural problems were highlighted. Xu (2005) noted that it was not effective to compete with the economic cycle only through the traditional macroeconomic policy, and science and technology became the key to reviving the Japanese economy. However, Japan's science and technology system and its policy before the reform were far from being able to adapt to new needs (p. 68).

As mentioned before, the most criticized part of the post-war Japanese science and technology policy and system was its failure in paying enough attention to basic science. According to the Ministry of Education, Culture, Sports, Science and Technology (MEXT; 2003), although Japan's R&D expenditure and GDP ratio was higher than that of the United States, Germany, France and Italy since the late 1980s, the government's investment in science and technology was at a low level. In 1994, the ratio of the government R&D expenditure in GDP was only 0.62% (0.53% in the natural sciences), while that in the United States was 0.91%, 0.95% in Germany, 1.10% in France, and 0.67% in the UK. The average researchers' R&D expenditure was 21.2 million yen, while in the United States it was 31.5 million yen in 1993, in the UK it was 28.1 million yen, in Germany it was 31.5 million yen in 1991, and in France it was 37.1 million yen. Another major problem in the Japanese science and technology system was that different departments (e.g., universities, government laboratories, and private companies), and researchers in different research areas hardly collaborated, which damaged science and technology innovation and the role of science and technology in promoting the economy. In addition, Japan's scientific research was not conducive to the growth of young scientists due to Japan’s unique system and the lack of a competition mechanism, such as life-long employment. The scientific research field was not attractive to many young people, which seriously affected healthy and sustainable science and technology innovation. Market-oriented research had a direct effect on economic development, but a lack of basic research and research would inevitably lead to great resistance to scientific and technological innovation. Basic research requires more government investment, and the government has to carry out a science and technology system reform. With increasing investment in R&D, and a flexible and efficient technology management system, Japan might achieve new scientific and technological breakthroughs.

Koji Omi, member of Japan’s House of Representatives, former Minister of Science and Technology of Japan, in 1995 stated the necessity of the Basic Law of Science and Technology to the House of Representatives. He further stated that the introduction of advanced technology from developed countries to Japan had ended, and that Japan had to innovate and explore new science and technology fields in the future. At the same time, to solve the lack of natural resources, the rapidly aging population, the industry hollowing out, economic liberalization, and globalization brought about by increased economic competition and other issues, Japan must develop unique, cutting-edge science and technology, and establish a new industry. A senior Japanese scientist also expressed the same view: Japan's post-war industrial policy was to catch up with the west in technology, with the technology strategy being to introduce science and technology from the United States and other western countries to promote industrial development. After the technology transfer and technological progress, Japan became one of the world's strongest economic powers. Now, Japan had to develop its own innovation system, otherwise there would be no technological breakthroughs, nor any new miracles. In short, both scientific and technological managers and scientists were clearly aware of the necessity and importance of the reform of the Japanese science and technology policy and system. According to Yang (2015), basic science became the engine to promoting comprehensive progress in science and technology. In the 21st century, Japan entered a new era of "scientific and technological innovation" (p. 30).

3.5 Breaking the traditional system and updating knowledge

Since the early 1980s, Japan began to realize that neglecting basic research may affect the sustainable development of the country's economy and science and technology. The Ministry of Education, Ministry of Science and Technology, and other government agencies and departments established and carried out several policies to promote science and technology, especially the development of basic research. In 1992, the cabinet office of science and technology proposed doubling R&D funding. Xu stated in 2005 the reason why the Basic Law of Science and Technology was passed and promulgated, and that the science and technology system reform started in the mid-1990s because Japan's political system reform underwent major changes at that time, and the technological system had changed correspondingly. The Liberal Democratic Party ended the history of one party ruling, a new government with other political parties was formed, and the “55 system” that was in place since 1955 came to an end (p. 69).

3.6 The reform of the political system and the promulgation of the Basic Law of Science and Technology

Japan's political system reform went through a process. The reform of the central government administrative system had been in place since 1996 and was formally introduced in December 1997. The core of the reform was to reduce the power of the central government departments, to reduce operating costs, and to improve the efficiency of the government through streamlining. A series of reform bills were approved by the Congress, including the reform of the cabinet system, the merger of government agencies and departments, and the reform of national universities and national laboratories. These policies and measures had a profound impact on the Japanese science and technology system and provided the conditions for the reconstruction of the scientific and technological system.

The Basic Law on Science and Technology clearly stated that it aimed to improve the level of science and technology in Japan. Of all the provisions, Article 9 was the most important. According to Article 9, the government should develop a basic plan to promote the development of science and technology every 5 years. The basic plan should contain a comprehensive and systematic approach to developing R&D (basic research, applied research, development research, and technology development), including research facilities, equipment, R&D information integration promotion, R&D environment construction and other related policies. To effectively protect the implementation of the basic plan, the government should take necessary measures to guarantee funding support within the national financial budget. All of the Japanese government's basic programs of science and technology (fiscal year 1995–2000, fiscal year 2001–2005, 2006–2010, 2011–2016) and a substantial increase in government investment in science and technology, the science and technology policy formation mechanism, and a series of reforms in the science and technology system are directly derived from the Basic Law (The Science and Technology Basic Law, 2017).

3.7 Re-understanding of the nature and role of basic research

For a long period after WWII, many countries, including Japan, followed the so-called “Linear model" to understand basic science and its relationship with technological innovation, from basic research and applied research to experimental development and production. Basic research is considered to be a special way to increase scientific knowledge without considering actual application. However, with the understanding of the scientific research and technological innovation process in the 1980s, the "parallel model", "Chain model", and "dynamic model" replaced the original "linear model". This proved the recognition of the important position of basic research in technological innovation and economic growth. Zheng, Guan, and Chen concluded in 2009 that the new science and technology policy embodied in the Japanese science and technology basic plan introduced in 1996 changed the post-war mode of Japanese science and technology policy, used a new perspective on basic research and its role, and managed to achieve a balance between basic research, applied research, and development research (p. 151).

3.8 The main measures of institutional reform

After the Basic Law of Science and Technology, fundamental reform was launched in the following three aspects:

3.8.1 Reconstruction of the science and technology policy system and mechanism

In 2016, Xue and Yang claimed that before the reform, a major flaw in the Japanese government's decision-making mechanism of science and technology policy was revealed with the development of the times. Although several departments proposed reform for their own benefit, no integrated organization was put in place to plan and coordinate the cabinet and Congress. The reform of the political system increased the power of the Cabinet and the Prime Minister, especially in policy-making, and the comprehensive coordination role beyond various departments.

On January 6, 2001, the Japanese government implemented a cabinet reform and established a cabinet office directly responsible to the prime minister. From a legal status, it was above other government departments, while the members were not only from relevant government departments, but also from civil and non-governmental organizations. One Minister of Science and Technology was in the cabinet office, while a "Comprehensive Science and Technology Conference" worked as the agency responsible for science and technology policy. Its size, organization, authority and responsibilities were greater than that of its predecessor—the original" Science and Technology Conference" was set up in 1959. Gong, in 2003, claimed the characteristics of the comprehensive science and technology conference fell within the following three aspects: (1) Strategic and timeliness. The agency was responsible for drafting a comprehensive science and technology strategy to discuss and research the allocation of scientific and technological resources, and the major national R&D activities and plans to carry out assessment. The agency was to be held once a month instead of 1–2 times per year, as done in the past. (2) Comprehensive. The discussion and formulation of science and technology policies under the new system included humanities and social sciences instead of only natural science, as was done under the old system. Therefore, important and broad issues such as science, technology, and society were considered in the science and technology policy at the comprehensive science and technology conference. (3) Autonomy. The new agency was more in the form of policy advice to the Prime Minister of the Cabinet, rather than passive response to the Prime Minister’s advice. In March 2001, in the second science and technology program, CSTC presented four important strategic science and technology fields, i.e., life sciences, information technology, environmental sciences, and nanotechnology / materials. They also announced the target of "generate 30 Nobel Prize winners in the next 50 years." In addition, the CSTC also worked with the Cabinet Office's think-tank organization at the "economic and financial advisory meeting" to play an important role in preparing and implementing national budgets. In June 2001, the Economic and Financial Consultation Meeting included the idea of "scientific and technological innovation" in its basic strategy, which maintained the status of the science and technology budget and included science and technology as one of the seven important areas for national finance in the specific budgeting of fiscal year 2002. Thus, the CSTC managed to change the decentralization of scientific and technological policy-making as well as the loose relationship between the development of science and technology and the state budget. It strengthened the strategy, and overall comprehensiveness of science and technology policy, and provided assurance for the further reform (p. 34-36).

3.8.2 Formulating and implementing the basic plan of science and technology

According to the Basic Law of Japan, the government will formulate a basic science and technology program every 5 years to increase investment in R&D, enhance the creativity of Japanese researchers, and to balance the relationship among basic research, applied research, and experimental development. Until now, Japan has developed four basic plans since 1996.

In the first basic plan, Japan planned to double investment in R&D in fiscal year 2000, and with the cumulative investment in R&D being 17 trillion yen, this was an astounding feat for the economic recession in the late 1990s. However, the most remarkable factor of the basic plan was that it clearly stated "building a new R&D system" to make science and technology more effectively linked to economy and society. The most important policy measures in the first basic plan included introducing tenure appointments in national research institutions and national universities. Thus, 10,000 postdoctoral researcher positions were created by the year 2000, changing the relevant provisions of intellectual property rights, softening the national university research staff part-time restrictions for cooperation between industry and academia, changing the traditional funding model to increase the proportion of competitive funding, introducing a strict and systematic evaluation process, applying evaluation results to the allocation of research funding, as well as improving the university's R&D facilities and equipment. Clearly, implementing some measures under the prerequisite of sufficient funds was easy, but changing the science and technology system and people’s ideas was not easy. Assessments of the implementation of the first basic program around 2000 also showed that people generally expressed satisfaction with the increase in inputs and the increase in post-doctoral positions. However, they were dissatisfied with the effectiveness of the technological and technological reforms.

The first basic plan improved the basis of the Japanese science and technology system, and the second basic plan was the reform of the scientific and technological system itself. In the second basic plan, the Japanese government's R&D investment continued to grow, with 24 trillion yen invested from 2001 to 2005. In addition to increasing investment, six main objectives of the basic plan were established: to determine the strategic direction of government R&D investment, to create a competitive environment for R&D, to improve the mobility of talent, to improve the R&D evaluation system, to enhance the application of research through the integration of government, industry and academia, and to promote the communication of science and society. The basic plan had two important initiatives in the scientific research system reform. First, competitive research funding was raised from 9% in 2000 to 15% in 2005. This was done to further expand the research staff on the selection of research topics and the use of autonomy for research to create an active environment. Evaluation activities could also be improved and an evaluation system that could maximize scientific creativity was established. Second, 30% of indirect funding was provided for competitive research projects that were managed by their institutions. The intended use of this funding was to improve access to competitive funds, to ameliorate a research environment, to improve the scientific research capacity of their institutions, and to promote competition among scientific research institutions to improve the quality of research (Cabinet Office, 2017).

3.8.3 Reform of science and technology management and scientific research institutions

According to the government reform law in 1999, Japan compressed the 22 ministries and institutions of the central government into 13, compressed the original government departments and agencies from 128 to 96, and the institutional advisory bodies were reduced from 211 to 89. Some national institutions (e.g., national laboratories, national hospitals, and national universities) were turned into "independent administrative agencies" and given larger autonomy in organizing and management. The most influential reform initiatives were MEXT being merged from the original Ministry of Education and Science and Technology Agency, and national universities and some national research institutions restructured as independent administrative agencies.

Under the old system, the Ministry of Education and Science and Technology Agency controlled nearly 70% of government research funding. Because of the different functions of the two independent departments, a competitive relationship existed between the R&D budget and technology policy orientation. Therefore, despite being national institutions, it was difficult for national universities and research institutes to cooperate under the different jurisdictions of the two departments. In addition, although the research funding managed by the Ministry of Education was the largest among the various government departments, each individual researcher could only obtain limited funding due to the large membership of organizations and researchers. Instead, individual researchers had to apply for funding at other departments and institutions (e.g., the Science and Technology Agency, and the Ministry of Real Estate). However, requirements differed for different channels of research funding, which was not conducive to researchers carrying out a stable study direction. Furthermore, different funds could not be unified for purchasing equipment, which was one major reason for the use of outdated equipment before reform. To change this situation, the two departments were merged on April 1, 2001. The newly established MEXT aimed to improve the research environment and conditions of the university, to promote the development of national universities and national research institutes, and to promote industry-government-academia integration (MEXT, 2004).

According to Gong (2003), another important step in the reform of science and technology in Japan was to change the national universities and some national research institutions into independent administrative agencies (p. 33). Japan's national scientific research institutions were established in the 1950s, collectively referred to as the national institutes, these were non-independent administrative agencies under the supervision of each province. For a long time, they conducted important R&D in accordance with the overall economic and social development needs. However, its operating mode was constrained by excessive administrative color. There were a set of strict management procedures, in the personnel, finance, budget, and business aspects, which made the research system rigid and reduced efficiency. Since April 2001, the reform established an independent administrative agency system, enabled flexibility, and freed those research institutes from old bureaucratic control. The focus of this reform was "de-administrative", to a certain extent, and it granted the national research institutions with innovation and vitality. In 2013, the Japanese cabinet proposed the idea of the world's most advanced research and development system, and passed the "basic policy for independent administrative agency reform" and other policy measures. In April 2015, the cabinet formally implemented the “The General Rule of the Independent Administrative Agency” (Amended), which further adapted to the law of research and development, and activated the vitality of research institutions’ innovations. According to the Rule, independent administrative agencies are divided into "national R&D agency", "medium-term target management agency", and "administrative executive agency" according to business characteristics. Among these, the national R&D agency is the most important part for Japan's long-term scientific and technological development strategy objectives. It carries out basic technology, and common technology research and development, while the characteristics of its R&D mission are long-term, uncertain, unpredictable, and professional (Yang, 2004, p.65-68). The main content of the reform are:

3.8.3.1 Implementation of a long-term target management system

The national R&D agency dedicates the basic technology and common technology in which universities and civil organizations are willing to get involved. It establishes the long-term planning system integrated with the R&D council, and a minister is assigned to be in charge and a R&D agency is selected. The council (expert symposium) provides suggestions and discusses objectives. The minister in charge decides the long-term objectives. The R&D agency is responsible for detailed long-term planning (Yang, 2004, p. 69).

3.8.3.2 Legal representative (president) responsibility system

Second, the president of the research institutions is the legal representative in charge of overall operation and management. The president and the supervisors (employed from outside) are appointed by the minister in charge, while the R&D agency has the right to decide the internal structure, appointment, and removal of middle-level cadre. Contract appointment system, ability-related salary system and external evaluation system are popularized in the R&D agency (Yang, 2004, p. 69-70).

3.8.3.3 Stable government investment and marketization

Xu (2005) noted the primary source of funds for R&D agency was the government budget and competitive research projects funding. The government investment reached 70%, followed by crosswise income, such as business commissioning R&D costs (p. 70). Xia and Zhong (2016) noted that the government provided financial subsidies in the name of funds and policy concessions. At the same time, the R&D agency was encouraged to engage in profitable activities, and the capital corporate accounting system was usually used for financial supervision (p. 87).

3.8.3.4 Emphasizing and standardizing scientific and technological evaluation

In line with the implementation of the basic plan, the Cabinet approved the "Outline of National R&D Evaluation" in August 1997. In November 2001, the revised evaluation guidelines were approved. Xia and Zhong (2016) noted that government departments conducted evaluation activities based on guided evaluation indicators, and that some departments developed their own evaluation guidelines. Standardization and improvement of the evaluation and reasonable use of the evaluation results played an important role in allocating scientific research resources, science and technology policy-making, scientific research reform, and personnel system reform (p. 88).

3.8.3.5 The Comprehensive Science and Technology Conference attaches great importance to evaluation activities

Zhu (2009) noted that the Comprehensive Science and Technology Conference put forward a series of policy measures to reform and improve the existing evaluation system. To highlight the importance of evaluation, it set up an “Evaluation Committee” that was responsible for developing evaluation criteria, assessing R&D activities and allocating R&D resources (p. 108).

3.8.9 Establishing evaluation indicators and standardizing evaluation activities

Zhu (2009) also noted the government introduced comprehensive evaluation indicators, and clarified the evaluation object and the responsibility of each part. For different types of evaluation objects, it answered what to assess, when to assess, how to assess, and who would assess. The principles and scope of the assessment, as well as the problems were clarified by the government (p. 109).

3.8.10 Goal-oriented performance evaluation

Together with the transformation for the independent administrative agency, the evaluation standard also changed from "efficiency" to "results". After implementing the medium-long-term objectives, the minister in charge would conduct a summary analysis on the necessity of the research institution construction, the organization operation and other business activities according to the evaluation results together with improvement measures, which was promptly published to the public to obtain public support (Xu, 2005, p. 72).

3.9 Summary

This chapter reviewed Japan's reform in the science and technology system, analyzed its motivation, and concluded 10 factors that were optimized to create a better environment for scientific research. In the next chapter, features of CAS's reform are conducted to determine differences between Japan and China.

Chapter 4: Features of CAS's reform

4.1 Reform background

According to CAS (2017), the CAS Pioneer Initiative (PI) is a direct result of a visit made by Chinese President Xi Jinping to CAS in July 2013. During the visit, Xi acknowledged CAS's significant past contributions; he also offered clear instructions and advice on its course for the future. He particularly appealed to CAS to focus efforts on the frontiers of science, national needs, and the economy. Specifically, he urged CAS to be a pioneer in four areas: achieving a leap forward in science and technology (S&T) developments; setting high national standards for the cultivation of talent; building a national, high-quality S&T think-tank; and becoming a cutting-edge, world-class research institution.

After President Xi's visit, the CAS thoroughly assessed our situation and came to an important realization: it needed to resolve some fundamental challenges and obstacles that hindered discovery and innovation, such as fragmentation and low-level duplication in research that led to inefficiency. That really meant that the CAS had to change the structure and mechanisms of how research was organized and done. Without improving these areas, the CAS would not be in a position to serve as a pioneer in science.

In light of its strategic role and the competitive external environment, CAS had every motivation to strengthen its position and to focus its resources and energy on major issues and challenges. Although the CAS in years did make some attempts to reform itself, it never took serious actions to address challenges in structure and mechanisms, and to assure these fundamentals were conducive to progress and impact on major scientific issues and challenges. A modern organization, to succeed nationally and at a global scale, must constantly evolve in this way (CAS, 2017).

4.2 Restructuring of the CAS research institutes

The research institute is the basic unit for scientific research, and is considered the key to reform. According to the CAS (2014), classified by their distinct focus, goals and characteristics, the CAS restructured research institutes into four basic categories.

- Centers for excellence are committed to cutting-edge research at the frontiers of science;
- Innovation academies focus on major national needs and project-oriented research and development;

- Centers of large science facilities provide open research platforms such as particle accelerators, synchrotron light sources, and magnetic facilities, while committing to meeting the needs at the regional and national level;
- Feature institutes work on specialized challenges related to economy and social sustainable developments such as landslides, and water and soil conservation in arid areas.

This organization enables each unit or center under the PI to focus on certain types of research and challenges with high levels of interdisciplinary teamwork and collective use of resources. A unit under the PI can either be constructed based on talent from one or two institutes or from several institutes.

4.3 Adjusting the optimization of scientific research layout

Another key point of the reform was to adjust and optimize the scientific research layout, and further focus the scientific research strength on national strategic needs and the world's science and technology frontier. Initiatives would cover seven aspects: planning a strategic research area, emphasize basic research, strengthen national defense innovation, develop new technology according to new industry, promote technology for population health and sustainable development, focus on the national major mission, and optimize the resource allocation system (CAS, 2014).

4.4 Improving the employment mechanism

The CAS will attract talent through global recruitment, and introduce an international assessment mechanism for high-end talent to improve the quality of the introduced talent. Meanwhile, it will also establish a "Distinguished Researcher" system to strengthen the stable support and incentive protection for innovation leaders and young scientists (CAS, 2014).

4.5 Setting up a national science and technology think tank

The think tank has always been one of the main functions of the CAS. The reform focuses on establishing a new system to strengthen the output orientation. The specific measures are to coordinate the relevant research strength and resources, establish a science and technology strategic consulting institute, improve the major topic selection mechanism, and enhance strategic research (CAS, 2014).

4.6 Strengthening the industrialization of technological achievements

The CAS will build a science and technology service network (STS Network) to promote the transfer and transformation of knowledge and technological achievements. It will focus on developing new industries, pillar industry upgrading, modern agriculture development, natural resources and ecological conservation, urbanization, and urban environmental governance. Furthermore, the CAS will combine existing resources and platforms, then build a scientific service system and platform to promote the industrialization of scientific achievements. Furthermore, it will also improve incentive support policies to encourage scientists to start businesses with their innovation achievements (CAS, 2014).

4.7 Summary

This chapter reviewed the features and intention of the CAS's reform. Different economic and social backgrounds, development ideas, strategic focus, scientific investment, as well as different administrative structures were analyzed by scholars and experts. In the next chapter, two case studies will be put forth in an attempt to reveal some factors from a micro level.

Chapter 5: Case study

5.1 Introduction

To conduct a comparative study analyzing the differences between scientific research in Japan and China, the researcher launched two case studies: one focused on the comparison of science policy carried out by Japan versus that by China for national scientific research. The other focused on two scientific research projects carried out by the same researcher, who was a research fellow at the Tokyo Institute of Technology, and now a research fellow at the Institute of Microsystem and Information Technology, CAS in Shanghai. The researcher tried to compare the projects from a policy level and from an individual level, and thus conveyed some findings to the research questions.

5.2 Case Study: Science project in Japan and China

The normal salary structure at the CAS research institutes abides by the 20-80 rule, which means financial appropriation covers 20% of the scientific researcher's income, and the remaining 80% has to be competed with. The CAS has 104 institutes, with each institute having seven to eight laboratories, and each laboratory comprising five to eight research groups. This totals to approximately over 5000 research groups. The research fields differ from institute to institute, however, many research institutes share similar research fields, and those research groups have to compete for funds, sometimes even within the same institute. Taking the National Institute of Advanced Industrial Science and Technology (AIST) as an example, there are 23 research centers, with each consisting of several research departments led by 10–20 scientists. The governmental appropriation covers 80% of AIST's research funds, with salary and allowance accounting for nearly 30%, which is almost the same proportion as direct research expenses. A case study of one scientific project may help with understanding the scientific research system.

5.2.1 Scientific research project in China

Professor Zhang, research fellow and director of the Bionic Vision System Laboratory in Chinese Academy of Sciences, was a scientific researcher at the AIST before returning to China. He was recruited by the "Recruitment Program of Global Experts" that started in 2008 as a national strategy attracting scientists and experts to work on breakthrough key technology, to develop high-tech industry and lead new subjects.

In 2013, he was appointed as director of the Bionic Vision System Laboratory at one of the CAS institutes. One of his most important missions was to apply scientific projects to develop the laboratory. In August, professor Zhang was informed that the CAS opens applications for key projects on international collaboration. After discussion with his colleagues, he decided to apply for a project with bionic eye research. The basic application procedure is:

1. The science and technology department of the institute informs the applicant, and provides an application form and consultant
2. The research group starts the application (online)
3. First trail is conducted by the laboratory
4. First trial is reviewed by the science and technology department
5. The trial is approved by the institute director
6. The news is delivered to the CAS headquarters
7. The research is reviewed by the experts organized by the CAS headquarters
8. A project interview is conducted by the experts
9. The experts inform the applicants with the result
10. The research group signs a contract or plans a task book
11. Research funds are allocated
12. Formalities of project funds use are completed
13. Project starts
14. Mid-term examination is conducted
15. Final examination and evaluation are conducted

All of the applicants need to calculate their budget based on “Interim Measures for the Administration of Major Civil Capital Projects.” The fund consists of direct and indirect costs.

The direct costs include:

1. Equipment costs

2. Material costs

3. Test and processing expenses

4. Fuel costs

5. Travel expenses

6. Conference expenses

7. International cooperation and exchange expenses

8. Publication / literature / information dissemination / IP costs

9. Remuneration

10. Expert consultation expenses

11. Infrastructure construction expenses

12. Other expenses

Indirect costs refer to costs incurred by the project (subject matter) in the organization of the implementation of the major project that cannot be included in direct costs. They mainly include existing equipment and housing, daily water, electricity, gas consumption, and consumption expenses provided by the unit for the project (subject) research, and related expenses of the unit according to the researchers' incentives.

The indirect costs shall be approved by the CAS headquarters on the basis of the characteristics of the major projects, the characteristics of the project (subject) and the nature of the project (subject matter). The indirect costs are generally not more than 13% of the remaining budget after deducting direct equipment purchase costs and capital construction fees. The relevant expenses according to the researchers' incentives are generally not more than 5% of the remaining budget after deducting direct purchase fees and capital fees.

Furthermore, the research institute will collect management fees in accordance with the following percentages:

1. Project budget less than 1 million Chinese yuan (8%)
2. Project budget from 1 million to 5 million Chinese yuan (5%)
3. Project budget from 5 million to 10 million Chinese yuan (2%)
4. Project budget more than 10 million Chinese yuan (1%)

As a prerequisite, the research institute has to match the monetary amount to the applicant's budget. For instance, if one applies for a project with a 5 million yuan budget, the research institute must also invest 5 million yuan. After calculation, professor Zhang applied for a 6 million yuan budget. Additionally, after a long period of reviewing and checking, his project was approved in March 2014, with a budget of 4 million yuan. Together with the investment from the institute, he received 8 million yuan in total. The equipment expenses and infrastructure expenses totaled almost 5,000,000 yuan, according to the above-mentioned rules, while the amount he was able to use for personnel salaries was 0.05*(8,000,000 − 5,000,000 = 150,000 yuan. Moreover, he gave 200,000 yuan to the research institute as a management fee. At that time, five people were working under his supervision, which meant that everyone received an average of nearly 25,000 yuan from the budget to conduct the research project. Meanwhile, the yearly average salary for Shanghai in 2013 was 60,435 yuan. In other words, the research group needed to win more than two projects to meet the life standard of Shanghai. However, the effort and time consumed in one application meant that they were already exhausted. Piles of application forms, documents, qualifications, certificates and interview needed to be prepared. This preparation work was only at the CAS level; at the national level, the competition and formalities were more severe.

Another issue was that the research funds often arrived late. For Professor Zhang's project, the actual allocation was received on January 2015, almost 1 year after approval. Being a 2-year project starting in March 2014 and ending in March 2016, they had to wait almost 1 year to conduct the project. Furthermore, they had to spend their entire budget prior to March 2016, otherwise the money would be withdrawn. This happens with almost all research projects, thus rushing the expenditure of surplus funds before the end of a fiscal period is a popular occurrence in scientific research.

5.2.2 Scientific research projects in Japan

While Professor Zhang was working at the Tokyo Institute of Technology, he applied to some research projects. The same factors will be listed for analysis. The Research Institute of Science and Technology for Society (RISTEX) conducts R&D programs with the aim of producing and promoting innovative solutions to the issues that human society confronts. To gain practical wisdom and methods that will lead to solutions on social issues, in addition to the R&D programs, RISTEX runs programs to support implementation and distribution of R&D results to society.

In May 2011, Professor Zhang discovered RISTEX information online that they had opened an application for scientific research in his field. The schedule was also published online:

1. Beginning of application (May 10, 2010)
2. First review deadline (June 26, 2010)
3. First review result (Mid of July, 2010)
4. Second review deadline (Mid of August, 2010)
5. Second review result (End of August, 2010)
6. Interview (September 4, 2010)
7. Interview and introduction (Mid of September, 2010, estimated)
8. Publish result (September to October, 2010, estimated)
9. Project begins (October, 2010, estimated)
10. Project review (October, 2012, estimated)

Applicants would also need to calculate the budget based on direct and indirect expenses.

The direct expenses included:

1. Equipment and consumables expenses
2. Travel expenses
3. Remuneration
4. Others

According to RISTEX (2010), the indirect expenses were expenses necessary for the management of research institutions, and in conducting research and development, which was basically up to 30% of research and development expenses (direct expenses). The executing agency should comply with the "Common Guidelines for the Execution of Indirect Expenses of Competitive Funds" in using expenses, and it was necessary to prepare policies concerning their use, their systematic and proper execution, and to ensure transparency of use.

For those who used the research funds improperly, the punishments were very severe. For example, those who embezzled research funds could face 10 years' imprisonment.

Professor Zhang's application was approved on October, 2010. A 10 million yen fund was allocated at the beginning of November. He did not need to pay any management fees to his university, and he and his two research assistants could use the fund to conduct scientific research freely. As a research fellow at the university, Professor Zhang was given a yearly salary of approximately 10 million Japanese yen (approximately 600,000 Chinese yuan) to carry out his research. The two research assistants were given approximately 6 million yen every year.

According to the Ministry of Health, Labor, and Welfare the yearly average salary in Japan was approximately 3.3 million Japanese yen. The income of the scientific researchers is relatively high in Japanese society. Moreover, the scientific research equipment and infrastructures were sufficient enough, hence this investment was relatively lower than that in China.

5.3 Interview and discussion

On February 14, 2017, the researcher went to China to conduct interviews for the report. Up to 15 researcher assistants, 10 assistant researchers, five associate researchers, and two research fellows were interviewed on their perspectives and the problems their scientific research faced, together with suggestions for reform. At the headquarters of the CAS in Beijing, one division chief and one deputy director-general were interviewed about the reform of the CAS. On the Japanese side, five assistant researchers, three associate researchers, and two research fellows were interviewed with the same questions.

The questionnaire used in the interview was based on the following questions:

I. How do you like scientific research?

A: 1 B: 2 C: 3 D: 4 E: 5

II. On average, how many hours do you spend on scientific research every day?

A: < 1 B: 1-3.5 C: 3.6-5.5 D: 5.5-7.6 E: >7.6

III. Are you satisfied with the current scientific research system?

A: 1 B: 2 C: 3 D: 4 E: 5

IV. Are you satisfied with your income?

A: 1 B: 2 C: 3 D: 4 E: 5

V. Do you expect some change for the current scientific research system?

A: 1 B: 2 C: 3 D: 4 E: 5

VI. What factors need to be changed?

(1 indicates strongly NO, 2 indicates MAYBE NO, 3 indicates HARD TO SAY, 4 indicates PROBOBALY YES, and 5 indicates strongly YES)

5.3.1 Chinese side

In total, 32 scientific researchers from China were interviewed by the author. Question I — 12 people answered C, 14 people answered D, and 4 people answered E.

Question II — 5 people answered B, 20 people answered C, and 7 people answered D.

Question III — 24 people answered B, and 8 people answered C.

Question IV— 15 people answered B, 12 people answered C, 2 people answered D, and 3 people answered E.

Question V — 4 people answered C, 6 people answered D, and 22 people answered E.

For question VI, most of the answers focused on:

1. A large number of institutions lack a system that has efficient innovation management capabilities
2. Technology investment is insufficient
3. Most researchers still lack high-level and international academic exchange opportunities
4. The public nature and transparency of the allocation mechanism of science and technology resources are insufficient
5. The overall cultural atmosphere of society is not ideal

5.3.2 Japanese side

Limited by time and resources, only 10 scientific researchers were interviewed.

Question I — 1 person answered C, 3 people answered D, and 6 people answered E.

Question II — 2 people answered C, 5 people answered D, and 3 people answered E.

Question III — 3 people answered B, 2 people answered C, 3 people answered D, and 2 people answered E.

Question IV— 1 person answered C, 5 people answered D, and 4 people answered E.

Question V — 5 people answered B, 4 people answered C, and 1 person answered D.

For question VI, most of the answers focused on:

1. Technology investment decreasing
2. Long-term research and new fields of research decreasing, while research organizations ask for quick success
3. Research subjects are segmented into very specific fields, and researchers know less about other fields, which impedes on the generation of new ideas
4. Academic fraud

Voices from senior scientific researchers:

When the author was in Shanghai conducting the interview, he undertook the opportunity to talk with one senior scientific researcher, who was a director at a laboratory of a CAS institute, and later became deputy director of that institute. The setting was in an informal occasion after a workshop with several researchers from Germany and Japan. While returning to the institute, he talked about his feelings on scientific research:

"I really admire those overseas scientific researchers, who could focus on their own scientific research. My interest is scientific research, I could do it all day, but now I am trapped in trivial administrative matters. Those overseas

research organizations hire special administrative experts to manage the daily operation, so that the scientists can dedicate themselves to research."

In August, 2016, the author visited the JST and conversed with Mr. Kazuki Okimura. He served at the Japanese Ministry of Education, Education, Science and Technology as former director of the Research and Development Bureau, Science and Technology Policy Research Institute, Chief Officer, scientific reviewer and was awarded the Japanese national civil service award "The Order of the Sacred Treasure". He also contributed significantly to Sino-Japan S&T exchanges, and received the Friendship Award, China's highest award for foreign experts who have made outstanding contributions to the country's economic and social progress.

During the conversation, the author asked the reason why Japan cultivated so many Nobel Prize winners. Mr. Okimura said:

"First, the scientific education for the young generation is very important. They are the future of the country. Second, most of the Japanese Nobel Prize winners went to study in the United States. Last, the relationship between research fellows and his students is like that of friends, a pleasant atmosphere helps to generate good ideas."

5.4 Summary

In this chapter, two case studies, interviews with scientific researchers and discussions with senior scientific experts provided different thoughts about the current scientific research environments in China as well as the ideas of reform. In the next chapter, the three research questions will be analyzed and discussed in detail.

Chapter 6: Findings and Analysis

6.1 Introduction

This report aims to study the advantage of Japan's science and technology system, determine the main factors of its advantages, and contribute ideas for the reform of the CAS. Through a literature review, analyzers, scholars, and experts have summarized various reasons why Japan is strong in science and technology, the disadvantages of China's science and technology system, and what China could learn from Japan. However, no article has conducted an overall perspective for how the Japanese science and technology system can benefit the reform of the CAS. Thus, after two case studies, interviews, and discussions with scientists from both Japan and China, as well as inspiration from a literature review, this chapter addresses the three research questions raised at the beginning of the study: What factors make Japan successful in scientific research? What problems does the CAS encounter in terms of scientific research? What can the CAS benefit from Japan for its reform?

6.2 What factors make Japan successful in scientific research?

First, Japan is a country that attaches great importance to technological innovation. Over the years, Japan has adhered to the principle of "technology founding the nation" and "technology legislation". According to Chen, Tao, and Zhang (2015), the national system can be divided into three stages: 1) Use industrial applications to promote relevant technology research and development of a reverse national innovation system, or national technology innovation system. Use science and technology research to promote industrial development or even a breakthrough in the national innovation system. 2) Concern about people's livelihood and environmental protection. Japan has formulated the goal of developing people's livelihood technology: creating new value through science and technology and service, promoting productivity, promoting sustained economic growth, and a win-win environmental protection. 3) Promote the integration of IGA. "Innovation" is the source of the development of the Japanese national economy; as the main promoter of the IGA, the Japanese government has provided a series of policy guarantees and developed environments for promoting the cooperation of the three parties, and has promoted the diversification science and technology policy activities (p. 43).

Second, Japan attaches great importance to knowledge creation (Li, 2012). It carried out rules and regulations to make knowledge creation the basic direction of science and technology policy. Moreover, it also regards the protection and use of intellectual property as a priority, which ensures the enthusiasm of the scientific researcher.

Third, the implementation of a scientific and technological talent strategy has become one of the main features of Japan's science and technology system (Yang, 2005, p. 33). Policies have been adopted for establishing a growth mechanism for talent, strengthening the training of innovative talents, and promoting the adjustment of talent structure.

Fourth, Japan always ensures investment in science and technology. After WWII, Japan never stopped investing in science and technology, and a "Science and Technology Basic Plan" was carried out in 1995, followed by a continuous plan to ensure the investment. According to the National Science Board, (2016) Japan's proportion of science and technology investment reached 3.5% of the GDP in 2013, ranked number 3 in the world.

Fifth, Japan pays great attention to basic research. The new science and technology policy embodied in the Japanese science and technology basic plan introduced in 1996 changed the post-war mode of the Japanese science and technology policy, used a new perspective on basic research and its role, and managed to achieve a balance between basic research, applied research, and development research (Zheng, Guan and Chen, 2013, p. 112).

Sixth, Japan has an effective administrative structure. Japan established a cabinet office and a comprehensive science and technology conference in charge of general science and technology management, and also ensured financial support for science and technology research. Another important act was the establishment of MEXT, which improved the research environment and conditions of universities, the development of national universities and national research institutes, as well as industry-government-academia integration (Chang & Wu, 2009, p. 61).

Seventh, Japan reformed the national R&D institutes into independent administrative agencies, enabled flexibility, and freed those research institutes from old bureaucratic control. The funding and management system were also optimized accordingly (Xu, 2005, 72).

6.3 What problems does the CAS face?

External influences and internal factors affect the scientific research of the CAS. External influences include the national policy, system, and social environment. Internal factors include the administrative structure, resources allocation, project management and supervision, and industrialization.

6.3.1 External influence

a. Low national R&D investment

R&D expenditure refers to the expenditure of the whole society on basic research, applied research, and experimental development in the statistical year. It includes the actual labor costs, raw material costs, fixed assets purchase and construction expenses, management fees, and other expenses incurred for research and experimental development activities. According to China's "Twelfth Five-Year Plan" proposed in 2010, the R&D expenditure in the GDP would be raised from 1.8% to 2.2% in 2015 (actual data = 2.1%). However, compared with Japan (3.39% in 2011), the proportion remains low. Low investment leads to a chain reaction that influences scientific research. Scientific researchers have to spend lot of time on competition for projects to obtain enough funding, which greatly affects their enthusiasm in scientific research.

b. The national science and technology project system is imperfect

The national science and technology program is a complete process from project initiation to implementation, and finally to acceptance. It involves the interests of the project applicant as well as the overall implementation of the national science and technology plan. This procedure not only guarantees fairness in science projects, but also protects the relationship that exists between participants involved in project management activities. At present, China's science and technology projects face several problems:

The R&D budget is unreasonable – scientific researchers are in charge of budgeting, with which they are unfamiliar. Furthermore, the R&D budget could substantially differ from the amount that the real projects need.

Li (2013) noted that R&D expenditure is not reasonable – some R&D funds are used for infrastructure, travel expenditures, or other expenses (p. 34).

R&D funding sources are complex, and difficult to manage – different funds granted from different channels have different requirements, which increases difficulty experienced in financial management (p.35).

Lack of an effective monitoring mechanism for R&D funding—no unified rules exist for the monitoring and supervising system of R&D funding. Low crime cost leads to indulgence in illegal behavior (p. 35).

c. Low social cognition

Since the Meiji Restoration, Japanese society has established a respect for science, and a respect for the atmosphere of scientists. The most obvious example is that, unlike most countries, Japanese banknotes are printed with scholars and no politicians. Printed on the most commonly used thousand 1,000 yen note, is the portrait of Noguchi Hideyo, who is a biologist in the study of yellow fever in Africa.

However, in China, scientific researchers are not considered to be as important as those in Japanese society, despite social class or personal income. The pursuits of materialism and blind entertainment overwhelm the advocating of science and technology. Among some institutes, scientific research is merely a job for living, rather than a path to achieving personal interests and ideals.

d. Administrative duties

The CAS is an organization with ministerial level in the government, with all the CAS institutes being bureau-level organizations. The president of the CAS usually serves as a deputy at the state level. Positively, the CAS always works as a think tank and has a large influence on national scientific policy making. However, Liu (2011) noted that scientists with administrative duties are always busy with daily administration affairs, political tasks, and that some even dedicate businesses in pursuit of political status (p. 59). There are several disadvantages to scientific research institutes that also act as administrative organizations. First, property rights are unclear. Theoretically, the ownership of those institutes belongs to the whole people, but the government is the actual supervisor. Those institutes lack subjective initiative and autonomy. Second, with regard to personnel management, equity distribution and funding allocation are rigid. The government administrative system does not match scientific research. On the contrary, it sometimes impedes science and technology development.

6.3.2 Internal factors

a. Unnecessary competition and wasting resources

While the CAS institutes make great progress, the development of the institutes is also accompanied by a serious problem: homogenization. Research institutes that engage in basic research are also engaged in technology development and even engineering. For one research subject, there exist dozens of project-allocated funding for different research groups in different institutes. Scientific researchers spend much time writing proposals, and conducting research that others are researching at the same time. Furthermore, those who focus on application technology also strive to publish articles. The internal competition is intense and institutes in the same field are competitors, so no cooperation exists among them. Within those research institutes, the research groups are fragmented, struggling for the project and for funding. This system has seriously weakened the cohesion of front-line researchers, and reduced their sense of identity in a subtle way (CAS, 2014).

b. Weak industrialization

Qing (2012) noted that industrialization is a complex and systematic process, which involves government, market, and research institutes. These three parties are interrelated with each other and determine the transformation from science and technology to social productivity (p. 118-119). The research institutes are the main body and engine to generating achievement. However, at the management level, the relative policies lack of implementation, and sophisticated procedures dispel the enthusiasm and positivity of those scientific researchers. The small proportion in the budget for transformation of scientific and technological achievements also fails to provide support to industrialization.

In 2010, Wang Zhizhen, vice chairman of the National Committee of the Chinese People's Political Consultative Conference and academician of the Chinese Academy of Sciences, highlighted that at present, the conversion rate of scientific and technological achievements in China is approximately 25%.

Furthermore, real industrialization is less than 5%. These figures are far below the 80% conversion rate of developed countries.

Many scientific projects are initiated with the aim of applying for projects, awards, and patents, instead of with the aim of transferring projects into products and commodities. Qing (2012) stated that the assessment system only focuses on SCI papers or capacity to compete for projects (p. 116). Last, the incentives are far from satisfying to encourage scientific researchers to transfer their achievements.

c. International exchange

"The most important thing for researchers is to go abroad and communicate with people of different ideas." (Bening, n.d.), President of the European Geochemistry Association once said. Good international collaboration not only updates knowledge, but also promotes re-innovation through cooperation, and stimulates development. At present, according to CAS's own analysis, the problems in its international collaboration are:

1. The collaboration stays at the knowledge exchange level through international symposiums, workshops, or visiting. Technological-level collaboration is still weak.

2. The exchange is always organized by the headquarters, adopting a top-down form.

3. International exchange expenditure is insufficient, and the application, approval, and reimbursement procedures are very strict and complicated.

4. Shortage of scientific researchers with good skills and English ability, as well as the ability to communicate.

5. The evaluation system focuses on short-term results.

6.4 What can the CAS benefit from Japan for its reform?

The purpose of the reform of the CAS is to optimize the allocation of government resources and social resources, improve the efficiency of scientific and technological innovation, and strengthen the combination of social and economic construction. At present, the international economy is in recession, and China is restructuring its economic structure. The government is facing national defense, people's livelihood, education, and many other pressures and eagerness for the ability to conduct independent innovation. The CAS, with a relatively simple organizational structure, is a good example for institutional reform. This report attempts to provide tentative factors from three different levels that the CAS could learn from Japan.

6.4.1 Large level – national level

1.1 In 2013, following the example of Japan, China launched an overhaul of its Central Ministries. The State Council cut the number of its ministry-level bodies from 27 to 25, while reorganizing several other agencies and departments (China Daily, December 12, 2013). The aim was to solve duplication of functions, overlapping management, and inefficiency and bureaucracy, which led to corruption and dereliction of duty.

When MOST was established, the CAS was put into an awkward position. The functions of the CAS could be replaced by MOST. The CAS bore a great proportion of the national scientific research mission and expenditure, and was independent from the management system under MOST, which increased administrative costs and caused overlapping management and duplication of functions. Thus, the first suggestion was to combine the CAS with MOST to create a single management agency for science and technology.

1.2 De-administration of the scientific research institute. Liu (2011) noted administration to be a hierarchical management model, which emphasizes superior leading subordinate (p. 60). However, administrative management may not work well in scientific research. Scientific achievement does not simply occur after superior requirements. It has to obey certain laws. Moreover, administrative duties may increase the burden of scientific researchers because they have to spend much time on administrative tasks. Some may even dedicate themselves to a political career instead of to scientific research. Thus, de-administration and a corresponding management system may contribute to providing fundamental changes in the reform.

1.3 Increase investment in science and technology R&D, especially in basic science and innovation. Human resources is always the most important resource for scientific research. Providing a stable environment and relevant facilities helps scientists in writing proposals and competing for funding. The more time they can spend on research, the more achievements can be expected.

6.4.2 Medium level – institutional level

a) Encourage industrialization. The reform of the CAS classified its research institutes into four types. Those focused on basic science may secure strong support from financial allocation, while others may compete in the market to survive. However, it is not easy for these institutes that for a long time are dependent on financial allocation or governmental projects to live on industrialization. Some high-tech enterprises are already engaged in the market with mature technologies and products. Many problems are experienced in the path to transferring scientific achievements into real products. To help institutes slowly adapt to the process, appropriate policy and financial support should be provided.

b) Improve the scientific projects system. According to Yang (2016), the process of scientific projects is not open, evaluations are not independent, and the supervision and management system focuses on punishing instead of preventing (p. 79). Some rules are so strict that scientific researchers resort to violating rules in order to obtain funding. Thus, the following are recommended: establish relevant rules and regulations for scientific projects, establish a reasonable evaluation object, abolish permanent positions, and introduce a third party for audit and supervision.

6.4.3 Small level – individual level

Increase welfare. Every individual scientific research is the smallest unit of scientific research. Aside from providing a salary to ensure that they do not need to worry about living, other welfare incentives such as the opportunity to study abroad, a part-time job in enterprises, and increasing the bonus of industrialization could be implemented. Moreover, training and emphasis on science morality are also very important for the reform.

Strengthening the popularization of science knowledge. Currently, popularizing science is facing the problem of limited influence. The public only obtains access to such knowledge through traditional media such as newspapers, magazines, or books. With the development of the internet, fewer people are in the habit of reading paper materials. Television and internet resources for popularizing science must be reconsidered to increase public awareness of science, and to establish a better social environment for science.

6.5 Summary

According to the literature review, case studies, interviews, and discussions with scientific researchers, three research questions have been answered. What factors make Japan successful in scientific research? What problems does the CAS in scientific research? What can the CAS benefit from Japan for its reform? The problems the CAS face do not exist only within the CAS; they can be seen as an epitome of the whole field of science research in China. From a comparative perspective, the CAS may learn lessons from the policy level to the individual level. The reform of the CAS is just in its infancy, and the path to reconstruction is still long.

Chapter 7: Conclusion

Science and technology innovation is the cornerstone of the rise of great powers. At present, China is on the road to rejuvenating the Chinese nation. Learning from Japan's experiences in the science and technology system provides great enlightenment for science development as well as social progress.

Japan’s advantages in the science and technology system are: emphasis on technology innovation; emphasis on knowledge creation; emphasis on talent cultivation; emphasis on investment in science and technology; effective administrative structure; and an effective form of research institute.

The problems that the CAS is facing are: low R&D investment; an imperfect science and technology project system; low social cognition, scientific researchers carrying out administrative duties; unnecessary competition and wasting of resources; and low industrialization and international exchange.

Tentative suggestion for the reform of the CAS are: combine CAS with MOST; de-administration of research institutes; raise R&D investment especially in basic science and innovation; promote industrialization; improve the scientific projects system; and increase scientific researcher welfare.

Constrained by time and efforts, this report did not analyze the negative aspects of Japan’s science and technology system. Some controversial perceptions about the “Basic Law for Science and Technology” argue against its negative impact on scientific research because it was short-term-achievements oriented. The idea of “what Japan could do for science and technology” changed to “what science and technology could do for Japan.” Too much emphasis on industrialization, reduction of R&D investment, and an increased number of fixed-term contracts made it difficult for scientific researchers to carry out research. Learning from these lessons may also be important for the reform of the CAS.

Moreover, over 62,000 CAS staff reside all over China, and the number that were interviewed for this report may only represent a small proportion of the researchers’ voices. Furthermore, this report only focused on Japan, and other countries such as the United States, Germany, and Russia may also be good examples. Further study may integrate advantages from different countries and generate better suggestions for the reform of the CAS.

Finally, it is hoped that through this tentative research on how to improve science and technology in China, the reform could really solve some problems that have long existed. It is very difficult to implement national-level changes, but at the institutional level, many factors could be refined. China could become better with the development of science and technology.

Bibliography

Bai, C. (2016). *The Pioneer Initiative: A New Era in Chinese Research*. Retrieved May 14, 2017 from http://www.cas.cn/xw/zyxw/yw/201411/t20141117_4253641.shtml

Chang, J., Wu, J. (2009). *A Comparative Study on the Latest Technological Innovation Policies between China and Japan*. Journal of Yanbian University (Social Science Edition). 2009 (42), 58-62. (In Chinese)

Chen, G., Tao, P., & Zhang, X. (2015). *Japan "Science and Technology Basic Plan" assessment analysis and its implications for China*. China Science and Technology Resources Guide (1), 49-56.

Chinese Academy of Sciences (2017). *English introduction*. Retrieved April 3, 2017, from http://english.cas.cn/about_us/introduction/201501/t20150114_135284.shtml

Gao, Y. (2004). *Japan's IT Strategy and Talent Training*. Foreign Social Sciences. 2004 (4), 61-66. (In Chinese)

Gong, X. (2003). *Constructing a System of Scientific and Technological Innovation of Economic Power - An Analysis of the Policy of Japan's Science and Technology System Reform.* China Science and Technology Forum (6), 32-36.

Gu, l., Zhang, Z., & Kang, J. (2009). *Patents and R & D Resources: Input and Output Analysis of China's Innovation*. Journal of Management Engineering. 2006

(1), 147 ~ 151.

Hu, J. (2011). *Seeing Japan's Science and Technology Development Strategy from the Basic Science and Technology Plan*. Academic Conference on China's Science and Technology Policy and Management (30), 116-120.

Japan Information Processing and Development Center. (2002) *Information White Book*. 2002 edition, 94-97.

Japan Information Processing and Development Center. (2002) *Monthly Bulletin of Economic Statistics*. 99.

Japan Information Processing and Development Center. (2003) *Information White Book*. (2000), 87

Japan Information Processing and Development Center. (2003) *Monthly Financial and Financial Statistics Monthly*. March 2003 version, 1-3.

Japan Information Processing and Development Center. (2003) *Toyobo Economic Monthly Bulletin*. 103.

Japan Ministry of Education, Culture, Sports, Science and Technology. (2004) *Science and Technology White Book*. 18, 210, 347, 249, 287, 301, 308 - 313, 346 - 347, 44, 210 - 211, 419, 222.

Japan Ministry of Education, Culture, Sports, Science and Technology. (2003) *Science and Technology White Book*. 9-13, 389.

Japan Trade Promotion Council. (2003) *Trade and Investment White Book*. 2003 edition, 81-82, 87.

Japanese Cabinet Office, 2017. Retrieved May 3, 2017 from http://www8.cao.go.jp/cstp/english/policy/panel.html

Jiang, N. (2013). *China's scientific research funding management problems and legal countermeasures*. Commercial Research. 2013 (4). 84 ~ 89.

Li, L. (2013). *Misuse of Scientific Research Funding*. Chinese Production Analysis. 2013(10) p. 34-35. (In Chinese)

Li, X. (2009) *On Inevitable Subjectivity of Science*. Journal of Social Sciences; 2009-01

Li, X. (2012). Journal of Dialectics of Nature, Chinese Academy of Sciences; *Three Divisions of Knowledge: Natural Science, Social Science and the Humanities*; Academics; 2012-08

Liu, S. (2005). *Japan's scientific and technological strength and the development of new trends*. Asia-Pacific Economic (1), 27-29.

Liu, S. (2011). *Research on Some Problems of "Dealing with Administrative" in Scientific Research Units*. Tropical Agriculture Engineering, 35 (6), 59-62.

Lu, Y. & Tang, L. (2014). Analysis of the Problems and Solutions of Science and Technology Policies in China. China Electronic Commerce (6), 109. (In Chinese)

Ministry of Science and Technology of the People's Republic of China. (2012). *International Science and Technology Development Report.* Beijing Science and Technology Literature Publishing House. (2012), 289. (In Chinese)

Ministry of Science and Technology of the People's Republic of China. (2013). *International Science and Technology Development Report.* Beijing: Science and Technology Literature Publishing House. (2012), 66. (In Chinese)

Ministry of Science and Technology of the People's Republic of China. (2014). *International Science and Technology Development Report.* Beijing: Science and Technology Literature Publishing House. (2012), 290. (In Chinese)

National Bureau of Statistics. Retrieved May 22, 2017 from http://www.stats.gov.cn/tjsj/tjgb/rdpcgb/qgkjjftrtjgb/201511/t20151123_1279545.html.2015,11 (In Chinese)

National Science Board. (2016). Science and Engineering Indicators 2016. Arlington, VA: National Science Foundation, NSB-2016-1. Retrieved May 28, 2017 from http://www.nsf.gov/statistics/2016/nsb20161/#/report]

Organization for Economic Cooperation and Development. (2017). *Main scientific and technological indicators*.

Qing, J. (2012). *Problems, Causes and Paths Innovation of Scientific Research Funds Management in China*. Journal of Hunan University of Finance and Economics. 28 (4), 116-121. (In Chinese)

Qiu, H. & Li, X. (2007) *Japan Science and Technology Policy History Compilation.* China Science and Technology Press. (In Chinese)

Strauss, A., & Corbin, J. (1998). *Basics of qualitative research: Techniques and procedures for developing grounded theory*. Thousand Oaks, CA: Sage.

Sun, Y., & University, T. (2013). *The analysis of synergetics qualitative research methodology in the social sciences*. Studies in Dialectics of Nature. (In Chinese)

The Science and Technology Basic Law. Retrieved February 3, 2017 from http://www.keguanjp.com/kgjp_baike/kgjp_bk_keji/pt20111105102602.html

Wu, J. (2010). *Japan government research institutions of the funding management model*. Science on the social impact. 2010 (3), 28 ~ 31. (In Chinese)

Xia, H., Zhong, B. (2016). *On the Enlightenment of Japan's Competitive Funds Allocation Mechanism to China's Innovation and Scientific Research Management. Education Management* 10 (3), 87-93. (In Chinese)

Xu, S. (2005). *Japan's Science and Technology System Reform and Its Enlightenment to China*. Heilongjiang Social Sciences (2), 68-72. (In Chinese)

Xu, Y. (2011) *Three Turns of Japan's Science and Technology Policy after the War and Its Enlightenment to China*. Shandong Economy. 2011(6), 83-88. (In Chinese)

Xu, Y. (2011). *Three Turns of Japan's Science and Technology Policy after the War and Its Enlightenment to China*. Shandong Economy. 2011 (6), 83-88. (In Chinese)

Xue, L., Yang, R. (2016). *How did the Japanese research institutions reform? - A detailed study of Japan's new R & D corporate system*. Retrieved June 1, 2017 from http://mp.weixin.qq.com/s?__biz=MzA3NTI3NTQ1NQ==&mid=2650435699&idx=1&sn=dbca9710aabb97a1cc90fda1a40cfc9b&scene=2&srcid=0728Hvuo04o2lTQeJbyVjDSn&from=timeline&isappinstalled=0#wechat_redirect (In Chinese)

Yang, L. (2016). *Problems and Countermeasures in the Management of Science and Technology Project.* Science and Technology and Innovation (10), 79. (In Chinese)

Yang, S. (2004). *Analysis of Japan's Science and Technology System Reform in*

Recent Years. Japanese Journal (2), 65-77. (In Chinese)

Yang, S. (2005). *Japan's recent science and technology policy analysis*. Japan study (3), 30-34. (In Chinese)

Zheng, Y., Guan, M., & Chen, X. (2009) *The Evolution of Japan's Science and Technology Policy after World War II: Historical Experience and Revelation*. Modern Japanese Economy. 2009 (4). 46-52.

Zheng, Y., Guan, M., & Chen, X. (2013). *Research on the evolution of Japan's science and technology policy and its execution after the war*. Science management research. 31 (5), 108-112.

Zhou, Z. (1998). Discussion on the Problems in China's Science and Technology Investment. Science Management Research (4), 65-66.

Zhu, F. (2009). *Analysis of the current scientific and technological funding management system in the existing problems and solutions*. Research and Development Management. 15 (5). 108 ~ 110.