Research Report

Technology Transfer from Academic Institutions through Science and Technology Intermediaries: Japan's Experience and Implication for China

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Certification Page

I, YAN Jianing (Student ID 51218630) hereby declare that the contents of this 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

Technology transfer from academic institutions is a complicated process of transferring scientific findings from academic institutions to parties capable of commercialization. In order to bridge the gap among different organizations, science and technology (S&T) intermediaries, which provide specialized services in any aspect of the innovation process, have been introduced to national innovation systems in many countries in the world. As the largest developing country, China's R&D funding enjoys a remarkable increase; however, the ratio of technology transfer is still way behind that in developed countries. The Chinese government is gaining momentum to promote S&T intermediary industry by putting forward the goal of building a socialized and networked S&T intermediary system towards specialization, large scale and standardization in its *National Medium-and Long-term Program for Science and Technology Development (2006-2020)*.

Japan was the first country achieved industrial success based on science and technology in non-European region. The establishment of many specialized S&T intermediaries is a key element of its reform of S&T system after World War II, which has successfully revitalized its economy. This report aims to uncover the successful factors of Japan's S&T intermediaries, and to provide tentative suggestions for China to develop its own.

The author started the research from literature review of journals and articles on China National Knowledge Infrastructure (CNKI) and Web of Science regarding the

status quo of both Chinese and Japanese S&T intermediary system. Based on the literature review, China's S&T intermediaries are facing challenges of no legal status but branches of the institutional departments, limited national guidance and incentive policies as well as shortage of professional talents. To the contrast, the Japanese government has created a legal environment for the establishment of technology transfer institutions and developed its S&T intermediary system at the national level through Japan Science and Technology Agency (JST) and private level through Technology Transfer Organizations (TLOs) established in each university. Therefore, the researcher researches the elements conductive to the construction of Japanese S&T intermediary system from two perspectives: legal environment and operation mechanism of national and private S&T intermediaries. Information and data are collected from government white papers, Ministry of Education, Culture, Sports, Science and Technology (MEXT), Ministry of Economy, Trade and Industry (METI) and the official website of organizations.

Then, the author studied Japanese policy regarding technology transfer from academic institutions, and found that S&T intermediaries in Japan were established under a set of legislations which ensured their legal status and cleared institutional barriers towards a formal channel of technology transfer. Moreover, government offered a bunch of policies to support their development both technically and financially. The case study of JST shows that it manages the country's overall technology transfer activities from a holistic and long-term perspective along the entire process of technology transfer, by means of funding market-oriented basic research, overarching

guidance on technology transfer activities in TLOs and dedication to national infrastructure construction and manpower development. Case studies of TLOs show that a market-oriented mindset is applied throughout the entire process from knowledge discovery and management to dissemination. In the meanwhile, coordination and clarification of the relationship with institution's intellectual property department and internal human resources development are two decisive factors for sound development.

It is concluded that the successful factors of Japanese S&T intermediaries are concluded as sophisticated laws and regulations, national guidance, market-oriented model, transparent information network and emphasis on talent development. Considering China is still in the process of deepening the reform of S&T system and S&T intermediary service is still in its infancy, tentative policy recommendation for China is to establish a specialized national organization to guide, assist and monitor the development of various S&T intermediaries, operate S&T intermediaries with market-oriented model and enhance supporting measures in terms of incentives, talent cultivation and information sharing network.

Chapter 1: Introduction

1.1 Research background

In the era of the knowledge-based economy, scientific and technological innovation has become a key factor in promoting sustainable economic development, which can be realized by transforming scientific and technological achievements into real productivity (Chen & Han, 2011). The definitions of technology transfer differ in different disciplines (Bozeman, 2000). At a micro level, technology transfer refers to the process of transferring scientific findings from universities and research institutions to parties capable of commercialization (World Intellectual Property Organization, 2006). Mechanisms of commercialization include consulting, collaborative research, patenting and spin-off companies (Landry, et al, 2006).

Technology transfer is a complicated process of cooperation among different organizations. Technology exists in the form of information, and requires funds, facilities and talents to become products (Gao & Gao, 2012). Originated in the west, science and technology (S&T) intermediaries or technology transfer organizations refer to organizations that provide specialized services in any aspect of innovation process ranging from technology evaluation, resource allocation, technology diffusion, decision-making and management consulting, etc. to facilitate technology transfer among universities, research institutes and enterprises (Zhou & Wang, 2009; Yang & Jia, 2004). As a bridge between enterprises and research organizations, S&T intermediaries play an indispensable role in technology transfer activities (Qing & Wang, 2015; Zhou & Wang, 2009). In 1997, they were recognized as a major player in National Innovation Systems by OECD (OECD, 1997).

As the largest developing country, China's R&D funding enjoys an annual increase of 20% in recent years, with more than 30,000 scientific and technological achievements accomplished every year (Gao & Gao, 2012). However, the ratio of them being transferred into real productivity is about 25%, with more than 80% achievements being put in mothballs, which is way behind the average transfer rate of 50%~70% in developed countries (Jia, 2002). Mismatching between the supply and demand sides of technological achievements is regarded as the main reason for the low transfer rate in China (Chen & Han, 2011). On one hand, research results from universities and research institutes don't target the market, which results in huge numbers of achievements on the shelf every year. On the other hand, technology suppliers encounter many obstacles in collaborating with appropriate demanders, and vice versa (Qing & Wang, 2015). Therefore, intervention is needed to bridge the gap between academia and industry. The Chinese government is gaining momentum to improve the construction of S&T intermediaries and put forward the goal of building an enterprise-led and market-directed technology innovation system featuring the integration of public institutions, businesses and intermediary organizations in its *National Medium-and Long-term Program for Science and Technology Development*

(2006-2020)[1].

Japan was the first country to achieve industrial success based on science and technology in non-European region (Fukasaku & Ishizaka, 2010). The establishment of many specialized S&T intermediaries is a key element of its adoption of "A Nation built on the Creation of Science and Technology" strategy, through which it has successfully revitalized its economy after World War II (Cheng, 2007). Japan prioritized science and technology innovation as a driving force for economic development. Later, it found that a large number of innovations were in the hands of universities and research institutes that could not be effectively transformed into productivity, which became a bottleneck that restricted the further development of Japanese economy. Since then, the nation upgraded national strategy to "A Nation built on Intellectual Property" (Takenaka, 2005).

Government has been playing an indispensable role in setting up S&T intermediary industry and promoting its development by means of creating a favorable policy environment, which is common practice in developed countries (Zhang & Wu & Liu, 2006). Though Japan started the construction of S&T intermediaries later than western countries, it has caught up with industry scale only second to the United States, thanks to the leading role government has played in promoting the development of S&T intermediary industry (Yang, 2003).

China and Japan are both in the East Asian cultural sphere. Although the political

[1] For more info as to National Medium-and long-term Program for Science and Technology Development (2006-2020), visit https://www.itu.int/en/ITU-D/Cybersecurity/Documents/National_Strategies_Repository/China_2006.pdf (last visited, 3 June 2019).

and economic systems of the two countries are different, they both have adopted the strategy of developing economy based on the advancement of science and technology (Jia & Pan, 2015). In 2006, China promulgated the *National Medium-and Long-term Program for Science and Technology Development*, followed by the releasing of China's *National Intellectual Property Strategy* in 2008, reflecting great similarity with Japanese science and technology policy development (Jia & Pan, 2015). Therefore, research on the formation and development of Japan’s S&T intermediaries in technology transfer system is of significance for China to build enterprise-led and market-directed technology innovation system.

1.2 Research questions

In light of the research background and literature review, this research aims to answer the research questions:

What elements are conductive to the construction of Japanese S&T intermediary system?

What can China learn from Japan for building a systematic science and technology intermediary system?

1.3 Significance

In the national innovation system, S&T intermediaries are an indispensable player to bridge the gap among universities, research institutes and enterprises (Zhou & Wang, 2009). The Chinese government has incorporated S&T intermediaries into the national innovation systems in *National Medium-and Long-term Plan for Science and Technology Development* and is gaining momentum of building a socialized and networked science and technology intermediary system towards specialization, large scale, and standardization. A sound and sustainable development of S&T intermediary industry is a driving force of increasing and systematic technology transfer from academic institutions, thus achieving economic development based on the advancement of science and technology.

1.4 Research aim and expectation

The aim of this research is to discover what elements are conductive to the construction of S&T intermediaries in technology transfer system in Japan, and to provide tentative suggestions for China to develop its own. Emphasis is put on how Japanese government makes macro policies to promote technology transfer by utilizing S&T intermediaries and how relevant organizations implement these policies and operate accordingly. Since China and Japan have great similarity in science and technology policy development (Jia & Pan, 2015), the conclusion is expected to provide a rational train of thought for Chinese policy-makers who are interested in formulating new policies on the development of S&T intermediaries, as well as for leaderships in Chinese public institutions who are responsible for the construction and operation of S&T intermediaries. Hopefully, this research will be an input for the formulation and operation of Chinese S&T intermediary industry, and promote the utilization of more scientific achievements in public sector.

1.5 Methodology

The study used qualitative methods of presenting findings through literature review and case study. Initial data were collected from literature review of journals and articles regarding the status quo of Chinese and Japanese S&T intermediaries from China National Knowledge Infrastructure (CNKI), Web of Science and government white papers. Based on literature review, the researcher discovered that Japan has created a legal environment for the establishment of technology transfer institutions and developed its S&T intermediary system at national and private level (Cheng, 2007). Japan Science and Technology Agency (JST) is the most influential public organization responsible for technology transfer of universities and research institutes at the national level while the Technology Transfer Organizations (TLOs) established in each university conduct technology transfer activities at a private level. Therefore, the researcher researches on the elements being conductive to the construction of Japanese S&T intermediary system from two perspectives: legal environment and operation mechanism of national and private S&T intermediaries. Information and data are collected from government white papers, Ministry of Education, Culture, Sports, Science and Technology (MEXT), Ministry of Economy, Trade and Industry (METI), the official website of organizations. Among the 35 Accredited TLOs in Japan, TODAI TLO of University of Tokyo and Kansai TLO of Kyoto University were chosen as two model TLOs for study. The reason for choosing TODAI TLO is that it has the most technology transfer revenues and cultivates the most start-up companies according to annual survey conducted by MEXT; and the reason for choosing Kansai TLO is that it has successfully reversed the deficit management by changing its business strategy and is regarded as best practice among TLO industry in Japan.

This paper is organized as follows:

I begin by describing the research rationale and, the next section is a review of former studies on the conceptual and empirical issues of S&T intermediaries and the status quo of Chinese and Japanese S&T intermediaries. In the third chapter, a study and analysis on government S&T strategy is presented, followed by the introduction and analysis of policies and mechanism on technology transfer system, especially the policy of introducing an intermediary organization "Technology Licensing Office (TLO)" to facilitate technology transfer of research results from universities and research institutes to businesses in Japan. In the fourth chapter, I investigate cases of Japanese national and private S&T intermediaries in their implementation of government strategy and policies as well as operation models to manage research results derived from universities. In the fifth chapter, an analysis of Japan's experience is concluded and policy recommendation is proposed in China's context, for the future development of S&T intermediary system, followed by a conclusion and limitations of the research in the last chapter.

Chapter 2: Literature review

2.1 Functions of science and technology intermediaries

Qin & Wang (2015) thought that the “adverse selection theory” well explained the necessity of S&T intermediaries in transformation scientific and technological achievements into commercialization. The theory of adverse selection holds that the choice of adverse selection lies in the information asymmetry of both parties. As both parties want to obtain the information that is most beneficial to them, they became distrust of the other party. Both parties would rather give up the uncertain high interest and would not be willing to bear the risk of missing information due to the risk of transformation. Therefore, intervention of intermediary agencies is necessary to achieve the equality of information in transaction. Smedlund (2006) defined S&T intermediaries as a middleman between knowledge producers and users from a functional perspective. The function of intermediary organization is interface management, including the establishment and organization of innovation systems, providing a platform for learning and experiment as well as strategic intellectual infrastructure to stimulate clearer needs, strategies and development. Howells (2006) considered S&T intermediary as an institution or entity that acts as a broker agent in two or more organizations in any aspect of the innovation process. S&T intermediaries are generally bridges between demand and supply, and can reduce obstacles in information exchange, results management, different organizational culture and cognition in the process of innovation. Hellmann (2007) pointed out the importance of technology transfer organization (TTO). TTO can find potential buyers for technological results with lower cost compared to individual scientists or research teams, which ensures researchers to spend more time on research and development without concerning technology transfer and intellectual property protection issues. As an intermediary organization between universities and enterprises, TTOs can help to improve the efficiency of technology transfer. Xu, et al, (2006) categorized S&T intermediaries into three types, which are knowledge application intermediaries, knowledge production intermediaries and knowledge transfer intermediaries. They pointed out the important function of S&T intermediary organization is to provide services for knowledge production, knowledge transfer, knowledge application, during which process intermediaries directly or indirectly engage in the production, transfer and application of knowledge. Gu (2006) pointed out that S&T intermediary organization is an important player in the national innovation systems, as it is an important driver that promotes technological innovation between research institutions and enterprises. It also proposes countermeasures to improve the specialized services and synergy capabilities of S&T intermediary organizations.

2.2 Operation of science and technology intermediaries

In a broad sense, the operating mechanism of S&T intermediary organizations refers to the existence of different types of S&T intermediary organizations from the perspective of the entire industry. In a narrow sense, it refers to the internal operation of S&T intermediaries in terms of how to improve the utilization efficiency of various resources and achieve sustainable development for a long time.

Ye (2004) compared the operational models of the China-US University Technology Transfer Centers and found that research results in China are more academic and passive about technology transfer. S&T intermediary organizations are relatively lacking in China's universities and research institutes. Peng, et al, (2008) proposed that the S&T intermediary organizations should form cooperation alliance, and put forward the objectives, coordination mechanism, decision-making procedures, credit system, and benefit distribution of the alliance of S&T intermediary organizations. Li & Yu (2008) explored the operation mode of Chia's S&T intermediary organization into the mode of the non-profit operation mode and for-profit operation mode. They pointed out that most of S&T intermediaries adopted a mixture of for-profit and non-profit mode of operation.

Some scholars have studied the operational mechanism of foreign S&T intermediary organizations. Han, et al, (2004) discussed the operation mechanism of the Japanese technology transfer organizations and categorized them into three stages: discovery and evaluation of scientific and technological achievements, the transformation of scientific and technological achievements, and the feedback after the industrialization of results. Thursby (2001) investigated the technology transfer institutions of 62 research universities in the United States and found that 71% of respondents believe that the major goal of TTO is to generate revenue through technology transfer, and 61% of respondents hold that promoting the commercialization of technological achievements is the secondary goal of the organization. As an independent institution, being profitable is a prerequisite for the existence of TTO. Zhu (2001) studied the promotion system of the US agricultural technology as a typical case to introduce the operation of the technology intermediary service system in developed countries, and then summarized inspirations for the construction and improvement of China's S&T intermediary service system, which included the scope of the S&T intermediary service system, the capacity building of S&T intermediary service system and the government's role in its development.

2.3 Government policies on science and technology intermediaries.

Mowery (1999) studied the University of California, Stanford, and Columbia to analyze the impact of the Bayer Act on technology transfer. The results showed that the Bayh-Dole Act promoted technology transfer, but it was not the only factor that drove the growth of university technology transfer. Bi (2006) analyzed the role of the government in the transfer of technology in universities and pointed out a series of regulations and policies that the U.S introduced to create a favorable policy environment for technology transfer, which had greatly mobilized the participation of government, universities, and industries. After summarizing previous studies, Li (2008) argued that laws, policies and regulations could guide the operation of S&T intermediaries, which required the government to take action and implement various policies. Debackere & Veugelers (2005) argued an appropriate mix of clear government policies with regard to property rights and ownership and incentive package policies are indispensable elements for a sustainable S&T intermediary service system development. Pollard (2015) analyzed characteristics of different kinds of systems of technology transfer intermediaries and suggested policy makers to put more emphasis on building human capital within intermediaries and information sharing networks in regional technology transfer activities. According to Wu (2008), the imperfect national legal system and policies are one of the factors hindering the development of China's S&T intermediaries. Therefore, relevant departments should formulate laws and policies as early as possible so that S&T intermediaries can give full play to their role.

2.4 Status quo of China’s science and technology intermediaries

Many scholars start from the status quo of the development of science and technology intermediary organizations and put forward corresponding development countermeasures.

Xiong (2007) discussed the main problems faced by China's S&T intermediary organizations, which include the uneven development among different regions, the unclear development orientation; the lack of competitiveness; and the lagging of development environment. Xiong also proposed to build a technology service network of S&T intermediary organizations to enhance the connection between regional innovation subjects. Zhang, et al, (2007) believed that China's S&T intermediary system faces problems such as uneven development, small industry scale and deficit service system, and proposed to promote the specialization, standardization and large-scale development of S&T intermediary organizations, improve government policies and laws, transform government functions, promote nurturing of professional talents, and accelerate the development of S&T intermediaries in backward areas. Chen (2009) researched the management of S&T intermediary organizations of the United States, Germany and Japan and pointed out that the development of foreign S&T intermediary organizations is worthy of China's reference to improve the operational mechanism of China's S&T intermediary organizations. Zhang (2009) analyzed the problems existing in China's S&T intermediary organizations in terms of policy environment, personnel quality and information acquisition. He drew on the experience of developed countries and proposed suggestions of standardization of government behavior, specialization of talent teams, marketization of operational mechanisms, and information sharing network building to promote the development of S&T intermediary organizations.

2.5 Development of Japan’s science and technology intermediaries

Woolgar (2007) investigated the reform of governance over national universities in 2004 had concluded that it had an influential effect on the organizational capacity, policies, incentives, etc. on national universities, which has reduced the obstacles of personal exchange. Li (2014) analyzed the macro environment factors of Technology Licensing Organizations in Japan and found the structure of TLOs had effectively promoted domestic technology transfer thanks to the direct and in-depth macro-policy of the Japanese government and the formation of the “intellectual property-technology-market” trinity of institutional objectives, institutional synergy, and institutional collaboration of TLOs. Ren, et al, (2012) studied Japan's technology transfer system and argued it is very systematic and has typical government-led characteristics, which emphasized on the collaboration of government, government-led policy implantation organizations and universities and research institutes. Cheng (2007) looked into the Japan Science and Technology Agency (JST) of its legal support system, main functions, organizational framework and operational mechanism and pointed out that JST's organizational framework, operating model and use and management of funds, etc., is worth learning to accelerate transformation of scientific research results from academic institutions. Ping (2006) studied Japan’s TLO mechanism and concluded that the TLO structure is a manifestation of the Japanese national innovation system featuring collaboration among industry, academia and government, which allowed the virtuous cycle of knowledge and revenue flow between academic institutions and industry.

Chapter 3: Japanese policy regarding technology transfer from academic institutions

3.1 Introduction

In the 1990s, an economic downturn after the burst of the bubble economy and rapid aging of population urged the Japanese government to revive the economy with no delay (Motohashi, 2005). Against this background, the Japanese cabinet realized the development of science and technology was a key factor in revitalizing the national economy and the former science and technology system was in need of reform. Thus, "A Program for Economic Structural Reform" was realized in 1996, in which it listed four areas, namely funds, human resources, technology and advanced information infrastructure, as key reform areas towards the building of a favorable environment for business and technology cooperation among industry, academia and government (Fujisue, 1998). The government came to aware that current businesses had focused on application research of new products for the sake of short-term economic return, while the importance of basic research, which can be hardly duplicated with long-term payback, was neglected; on the other hand, although many universities and research institutions have made breakthrough in basic research, the academia-industry link was weak and unable to transfer them into commercialization. Therefore, reform of the innovation system took place as one of the solutions to contribute to the structural reform of the Japanese economy. In this chapter, I will explore the development of Japanese S&T policy on technology transfer system, especially the introduction of S&T intermediary organization and their impact on technology commercialization.

3.2 National strategy for science and technology development

3.2.1 A nation built on the creation of science and technology

The promulgation of the *Science and Technology Basic Law* (the Law) in 1995 marked the beginning of Japan's reform in the scientific research system (Yin & Zhang, 2006). Japan shifted its catch-up S&T strategy of "Nation based on science and technology" towards the "Nation built on the creation of science and technology" to develop innovative technologies (Harayama, 2001).

The Law is the highest national S&T strategy set forth by the government towards the fulfillment of a nation based on ingenious science and technology, which emphasizes due attention to basic research and applied research, personnel exchange and joint research activities in R&D development. It also places the government accountable for formulating implementation policies in basic plans every five years, which should cover a comprehensive and systematic approach to develop different types of research activities with clear budgetary target based on anticipating the next decade[2].

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[2] For more info as to Science and Technology Basic Law, see https://www8.cao.go.jp/cstp/english/law/law.html, last visited 3 June, 2019.

The first Science and Technology Basic Plan[3] was launched in 1996, based on the guideline of "science and technology to be supported by the public, returning benefits to society", set the objective of reconstructing the R&D system. A series of measures was taken to fulfill the objective: to double government expenditure on R&D by the year 2000 of 17 trillion yen (148 billion US dollars); to increase competitive research funding; to nurture 10,000 young postdoctoral researchers by 2000; and to promote use of research results through collaboration among academia, industry and government.

In 2001, the Council for Science and Technology Policy[4] (later renamed as The Council for Science, Technology and Innovation, CSTI) was formed to take charge of the formulation and implementation of S&T basic plans. Presided over by the Prime Minister, it became the highest administrative organ in terms of S&T policies issuing in Japan, composed of 7 ministers related to S&T development and 8 executive members from industry and academia. They hold plenary sessions on a monthly basis, developing policies regarding the reform of S&T system, resource allocation, project prioritizing, etc. In the same year, the *2nd Basic Plan*[5] (2001-2005) was released, focusing on the promotion of R&D in prioritized areas, namely life sciences, information and telecommunications, environmental sciences, and nanotechnology/materials.

Up to now, five rounds of Basic Plans were released since 1996 (fiscal year 1996-2000, fiscal year 2001-2005, fiscal year 2006-2010, fiscal year 2011-2015, fiscal year 2016-2020), featuring expanded government expenditure on R&D against

[3] For more info as to the first Basic Plan, see https://www8.cao.go.jp/cstp/english/basic/1st-BasicPlan_96-00.pdf, last visited 3 June, 2019.
[4] For more info as to CSTI, see https://www8.cao.go.jp/cstp/english/policy/index.html, last visited 6 June, 2019.
[5] For more info as to the second Basic Plan, see https://www8.cao.go.jp/cstp/english/basic/2nd-BasicPlan_01-05.html, last visited 3 June, 2019.

prolonged economic stagnation in Japan; prioritizing basic research which was overlooked for many years because of rapid industrialization and key research and development areas of interest to the government and society; nurturing young researchers and retention of excellent researchers and engineers; promotion of academia, industry and government collaboration.

3.2.2 A nation built on intellectual property

In February 2002, Prime Minister Junichiro Koizumi declared that the nation would strategically protect and utilize the intellectual properties generated from public research organizations and efforts would be delivered to build Japan into an "IP-based nation", followed by the establishment of Strategic Council and Intellectual Property at the Office. Under the strong leadership of Prime Minister, Intellectual Property Strategic Headquarters and the *Basic Law on Intellectual Property* were introduced successively at the end of 2002 (Arai, 2005).

The Basic Law on Intellectual Property[6] was enacted in 2003. This law promoted measures for the creation, protection and exploitation of IP and clarified the responsibilities of national government, local governments, universities, etc. and business operators. In the past, ministries and agencies often competed for the jurisdiction over IP-related issues regarding new policies, which caused difficulties in developing a comprehensive IP policy for various departments to manage IP-related

[6] For more info as to the Basic Law on Intellectual Property, see https://www.cas.go.jp/jp/seisaku/hourei/data/ipba.pdf, last visited 3 June, 2019.

issues (Takenaka, 2009).

The Basic IP Law led the Japanese government to establish IP Headquarters within the Cabinet headed by the Prime Minister, playing an intermediary role between different government ministries and agencies and a central role in implementing IP policies. It consists of all Cabinet members and experts, to plan, develop and implement intellectual property strategy and deal with major tasks beyond the capability of a single ministry (Arai, 2005). The first Intellectual Property Strategic Program[7] was released in 2004 and various measures were taken centering on the IP creation, protection and exploitation tasks. In terms of IP creation, the Strategic Program instructs universities to set up Intellectual Property Headquarters and Technology Licensing Organizations (TLOs) to manage university output. In IP protection, it expedited the examination process of patents, setting the goal to hold the waiting period for less than 30 months when there were 800,000 applications waiting for examination (Arai, 2005). For exploration, it issued the Guideline for Intellectual Property Information Disclosure in 2004 and amended the Trust Business Law to facilitate the management and mobilization of intellectual property (Arai, 2005). Besides, IP management advisors are dispatched to universities and public research institutes for 3 years to direct university staff in IP management; patent licensing advisors are dispatched on the request of TLOs to support IP activities at universities and public research institutes.

[7] For more info as to the Intellectual Property Strategic Program, see https://japan.kantei.go.jp/policy/titeki/kettei/040527_e.html, last visited 3 June, 2019.

3.3 Technology transfer policies

In Japan, S&T activities are carried out within the scope permitted by law (Cheng, 2007). The Japanese government learnt from successful technology transfer experience of the United States, and launched a number of supporting policies in the 1980s based on Japan's context and gradually established partnerships among government, academia and industry. Japanese government plays a critical role in leading and coordinating different shareholders in technology transfer activities (Takenaka, 2005).

3.3.1 Act on special measures for industrial revitalization

One of the most prominent legislations is the *Act on Special Measures for Industrial Revitalization*, the Japanese version of Bayh-Dole Act. Intellectual property rights are the focal points in knowledge flow from public research institutes and universities to industry. Bayh-Dole Act was enacted in 1980 in the U.S and is one of the most influential policies to promote federally supported research into commercialization (Barratt, 2010). It allowed universities, small businesses and non-profit organizations to obtain the title of the inventions funded by the government, patent and license them to the private sector. Several studies indicated the number of patents applied by universities increased dramatically after the enactment of Bayh-Dole Act. Japan emulated the U.S Law and shifted the ownership of research achievements under the sponsorship of government funding. Before the introduction of this law, the intellectual property rights of university findings were owned by the government or the inventors.

For those results derived from government-funded projects, the intellectual property belonged to the government and patent applications were filed by the Japan Society for the Promotion of Science (JSPS) and licensed by the Japan Science and Technology Corporation (JST) (Kneller, 1999). For the rest of results belong to the inventors, in most cases the researchers chose to transfer them to enterprises in an informal manner in exchange of research fund. The Japanese Bayh-Dole Act allowed universities to hold title of those inventions and became capable of passing on creation to the society. It also stipulated measures of reduction and exemption of patent fees to encourage universities to license their achievements. However, national universities were government organizations at that time, few universities applied for the title because of complicated restrictions. The situation didn't change until the privatization of national universities in 2004.

3.3.2 Act on the promotion of technology transfer from universities to private business operators

In 1998, after drawing experiences from major universities in the U.S, Japan emulated U.S's Technology Transfer Office (TTO) model and introduced Technology Licensing Office (TLO) structure to universities through the promulgation of *Act on the Promotion of Technology Transfer from Universities to Private Business Operators* (the "TLO Act")[8]. The law encouraged universities to set up TLOs in accordance with the

[8] For more info as to the TLO Act, see http://www.japaneselawtranslation.go.jp/law/detail/?vm=04&id=93&re=02, last visited 3 June, 2019.

implementation guidelines stipulated by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) and Ministry of Economy, Trade and Industry (METI). TLO plays an intermediary role between academia and industry, mainly responsible for discovering, evaluating and screening research results; patenting results on behalf of universities or researchers; licensing out technologies to businesses and providing technical and business support for commercialization (METI, 1998). Universities intent to set up a TLO shall submit an implementation plan, containing information regarding the operator, the contents and implementation methods, implementation period as well as the amount of funds necessary for implementation to MEXT and METI for approval. The Ministers will make a public announcement of approved TLOs and METI incentivized the development of TLOs with public benefits.

There are two types of TLOs. Accredited TLOs approved by both MEXT and METI are entitled to enjoy government subsidies for up to 30 million yen for the first five years and other public financial support through the Industrial Structural Improvement Fund as follows, while Approved TLOs, who's responsible for technology transfer of state-owned intellectual property, shall be approved by ministers having jurisdiction over and can obtain the exemption from the royalties and handling fees, but they cannot obtain financial subsidies or loan guarantees.

- Grants of up to a maximum of 30 million yen and no more than 2/3 of the planned funding amount each year from the government (TLO Act);

- Exemption of patent registration fees for the first to the tenth year and reduction of patent maintenance fees by 50% (TLO Act);

- The national government’s approval for the transfer or licensing of a patent right, etc. held by a consignee is unnecessary with regard to outcomes of research and development consigned by the national government (Industrial Technology Enhancement Act);

- Capital contributions from national university corporations (National University Corporation Act);

- Debt guarantees from the Organization for Small & Medium Enterprises and Regional Innovation to enable the borrowing of funds necessary for implementing Specified University Technology Transfer Operations (TLO Act).

3.3.3 National university corporation act

In order to streamline government responsibilities and stimulate the vitality of research institutions, the Japanese government conducted substantial reforms of public research institutions as part of administrative reform since 1999. National research institutes and national universities were transformed into independent administrative organizations from 2001 to 2005 according to the *National University Corporation Act*. After this reform, national research institutes and universities were granted legal status and no longer under the jurisdiction of MEXT. They became independent legal entities called "Incorporated Administrative Agency". The term "Incorporated Administrative Agency" refers to a corporation or national agency involved in administrative execution for public benefits independently other than direct implementation by the government[9]. This reform equipped universities and research institutes with more autonomy and independency. At the same time, they bear increasing responsibility for competition. The government made changes in funding by reducing the institutional fund for universities' daily operation, while increasing the proportion of competitive funds to stimulate the collaboration between universities and businesses in joint research projects. It also regulated the government's legal management of research institutions (Clark, 2001).

Prior to 2004, under the principal set by the Ministry of Education that intellectual property discovered by researchers in national universities belonged to researchers, about 80% of patents in Japanese national universities belonged to individual teachers, and 20% of patents were state-owned (Zhang, 2010). Researchers had long-term cooperative relationships with businesses were more inclined to hand over their research results to large companies for patent application in exchange for extra funding, which made TLOs hard to sustain the quantity and quality of patent application obtained from individual inventors.

After the promulgation of the above-mentioned three major legislations, a new technology transfer system has been established, featuring the universities owning IPRs, the existence of TLO structure as an intermediary organization for technology transfer from academia institutions, and autonomy for national universities. Thus, a formal channel of technology transfer from academic institutions to industry was formed.

[9] For more info as to Incorporated Administrative Agency, see http://www.japaneselawtranslation.go.jp/law/detail_main?re=&vm=&id=2754, last visited 3 June, 2019.

Table 1: Policy evolution regarding rebuilding technology transfer system

Year	Legislation	Key Points
1995	Science and Technology Basic Law	Nation built on Creation of Science and Technology Strategy; Promote technology transfer from university/research institute to industry
1996	Science and Technology Basic Plan (1996-2000)	Construction of new R&D system
1998	Act on the Promotion of Technology Transfer from Universities to Private Business Operators (TLO Act)	Establishment of TLO
1999	Act on Special Measures for Industrial Revitalization	Japanese "Bayh-Dole Act"; results of national contract research belong to contractors
2000	The Industrial Technology Enhancement Act	Deregulated personnel in national universities by providing a legal basis for them to jointly hold positons as officers, advisors or councilors in TLOs and R&D start-ups; Reduction of patent fees; free use of national facilities, etc.
2002	Intellectual Property Basic Act	Establishment of IP headquarters
2004	National University Corporation Act	Legal status and independency of national universities

Source: Information collected from Cabinet Office and compiled by the author.

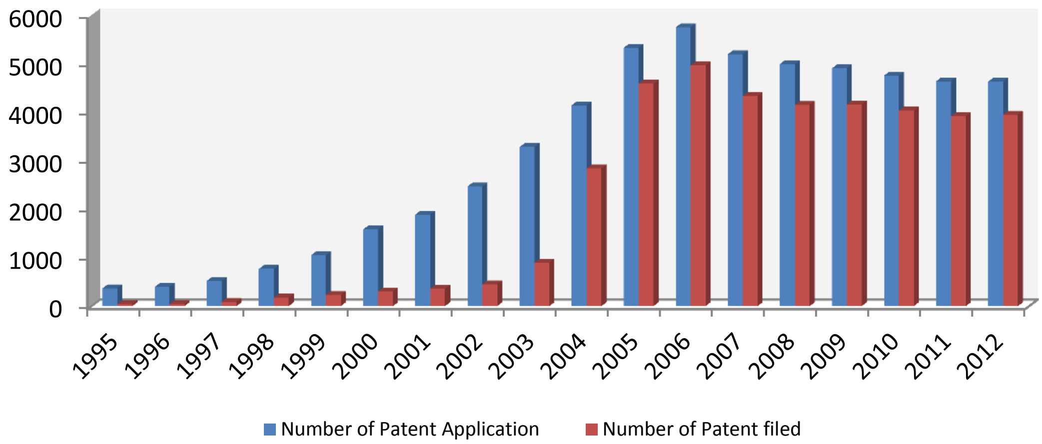
3.4 Performance of technology transfer

3.4.1 Patent application and licensing

The enactment of the above-mentioned laws stimulated patent-related activities in Japan's universities. According to the surveys conducted by MEXT on the performance of commercialization of research results from universities showed in figure 1, the number of patent applications and grants of applications from Japanese national universities increased year by year from 1995 to 2006. The number of patent applications increased from 368 to 5,751, and the number in 2006 was 15.6 times that of the number in 1995. During the same period of time, the number of grant patents increased from 42 to 4,969, which was 118 times that of 1995. Both numbers surged after the privation of the national universities in 2004: the number of grants has soared from 896 in 2003 to 2,842 in 2004, an increase of 217%, and kept soaring to 4,590, an increase of 62%. After 2006, patent numbers showed a downward trend.

The reason contributed to this trend is largely because of the transition of results' ownership and autonomy of national universities. Universities became holders of inventions and can conduct transfer activities independently. Besides, TLO's could receive financial relief in terms of IP related applications for the first to the tenth year according to TLO Act, and this explained the number of applications kept increasing since 1998 and stated to decrease after 2006 and remained stable afterward.

Figure 1: Evolution of patent number from national universities (1995-2012)

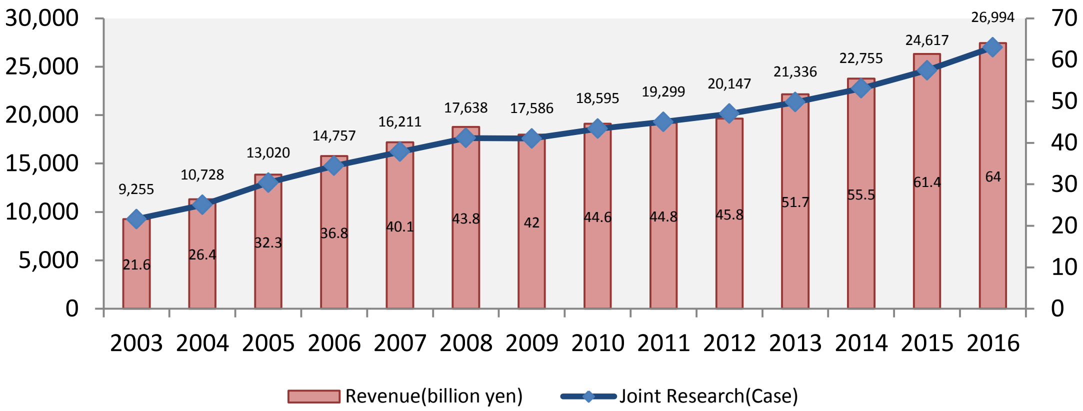


Source: Data collected from MEXT (http://www.mext.go.jp/a_menu/shinkou/sangaku/sangakub.htm)

3.4.2 University-industry cooperation

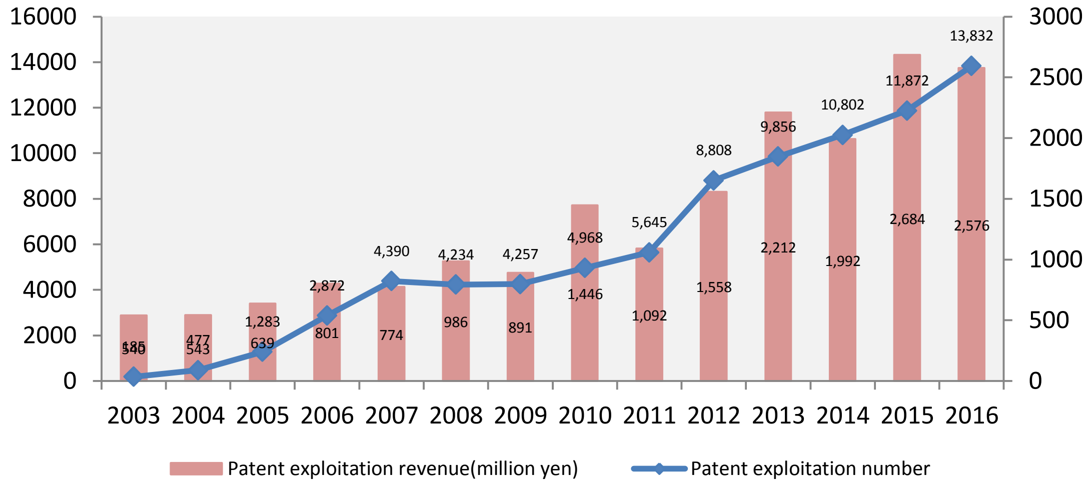
The collaboration between university and industry is essential in integrating public research with market needs. In the past, researchers in the universities focused on their basic research while paying little attention to the needs of the market. However, as MEXT cut down the budget provided for national universities after 2004, national universities were urged to find competitive funding to sustain their operation. Also, the legal obstacles of the IP ownership hindered the industry's participation in joint projects in the past. Due to the fact that national universities were not legal entities, they were not entitled to own patents, thus unable to transfer them to enterprises (Angelino, 2004). With the support of a series of technology transfer promotion laws such as the TLO Law and the Special Measures for the Revitalization of Industrial Capabilities, the university-industry cooperation in Japan has made continuous and significant progress (see figure 2): From 2003 to 2016, the number of joint research projects increased from 9,255 to 26,994, and the revenue derived from joint programs increased from 21.6 billion yen to 64 billion yen, both of which increased by a factor of two; During the same period of time (see figure 3), the exploitation number of patents increased rapidly from 185 to 13,832, the number in 2016 was 74.8 times of that in 2003; and the revenue of patent licensing increased from 5, 400 million yen to 2, 576 billion yen, only 4.77 times of 2003, which indicated that more patents were transferred to SMEs.

Figure 2: Evolution of joint research from national universities (2003-2016)



Source: Data collected from MEXT (http://www.mext.go.jp/a_menu/shinkou/sangaku/sangakub.htm)

Figure 3: Evolution of patent exploration from national universities (2003-2016)

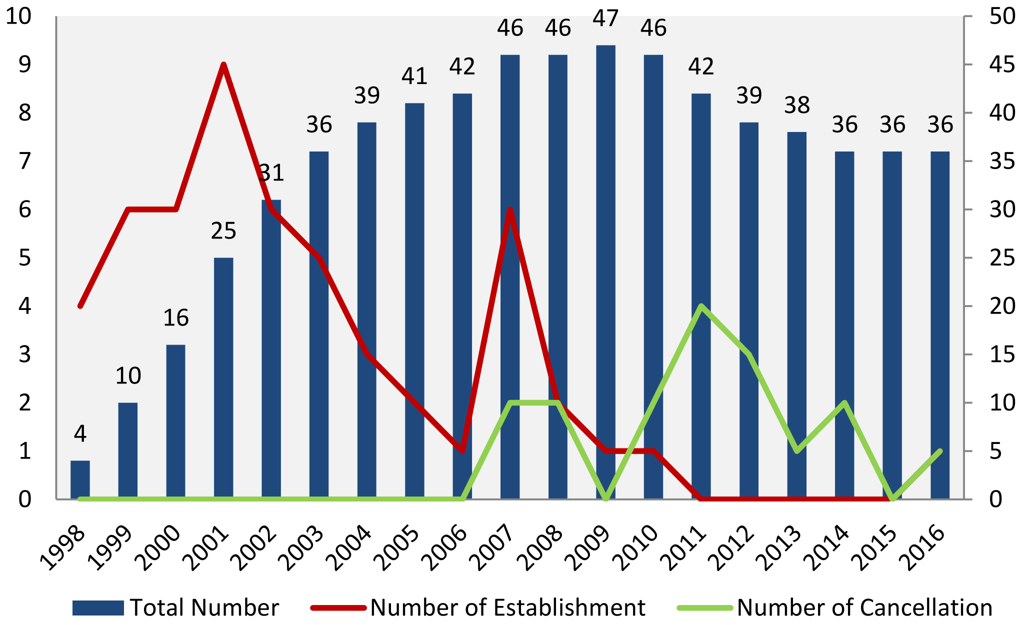


Source: Data collected from MEXT (http://www.mext.go.jp/a_menu/shinkou/sangaku/sangakub.htm)

3.4.3 Technology Licensing Office (TLO)

Since the introduction of *TLO Act* in 1998, the number of Accredited TLOs increased dramatically in the first three years and then enjoyed a steady increase till 2009, with the total number reaching a peak of 47 in 2009 (Figure 4). Stipulated by the above-mentioned policies, universities were able to handle their intellectual properties independently and became a source of universities' funding, therefore, an increasing number of universities set up TLOs respectively. Since 2007, the total number of Accredited TLOs began to decrease and maintained a stable number of 36 since 2014. According to a study carried out by Ministry of Internal Affairs and Communications (2016), main reason for cancellation of a certain number of TLOs is the difficulty in self-sufficient management, especially after the cease of government subsidies after the first five years of their establishment.

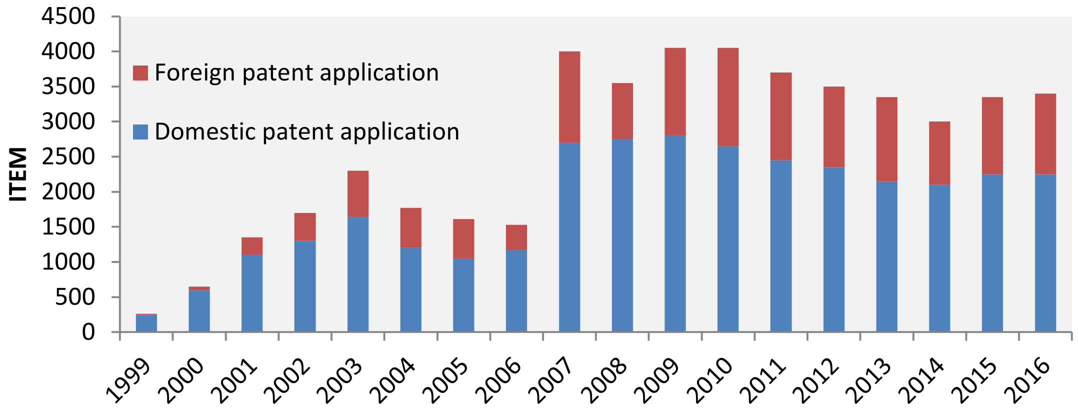
Figure 4: Evolution of the number of Accredited TLOs (1998-2016)



Source: Data collected from Japan Patent Office (https://www.jpo.go.jp/toppage/links/tlo.html)

The patent application number performed by TLOs is closely related to the number of patent application from universities and the number of Accredited TLOs. As discussed in the previous section, patent application and licensing number from universities surged after the privation of the national universities in 2004. The patent application related to TLOs surged in 2007, both in domestic and foreign applications (Figure 5). Increasing number of patent application from universities and growing number of Accredited TLOs might have jointly attributed to this surge in 2007 as six more TLOs were recognized in 2007 since the privation of the national universities in 2004 (Figure 4). Since then, the number of patent application related to TLOs shown a corresponding trend with the number of Accredited TLOs.

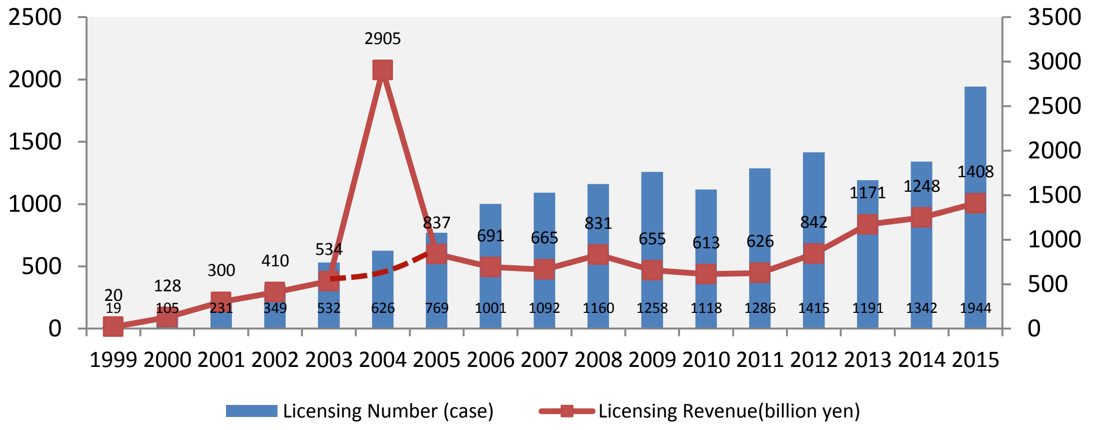
Figure 5 : Evolution of patent application related to TLOs (1999-2016)



Source: Data collected from MEXT (http://www.mext.go.jp/a_menu/shinkou/sangaku/sangakub.htm)

The number of licensing revenue involving Accredited TLOs presented a similar trend (Figure 6), which increased approximately 2.6 times between FY 2003 (before the incorporation of the National University in 2004) and FY 2014. In 2004, the number reached a record high of 2.9 billion yen on account of the income from stock sales of university start-ups (MEXT, 2004).

Figure 6: Evolution of Licensing Number related to TLOs (1999-2015)

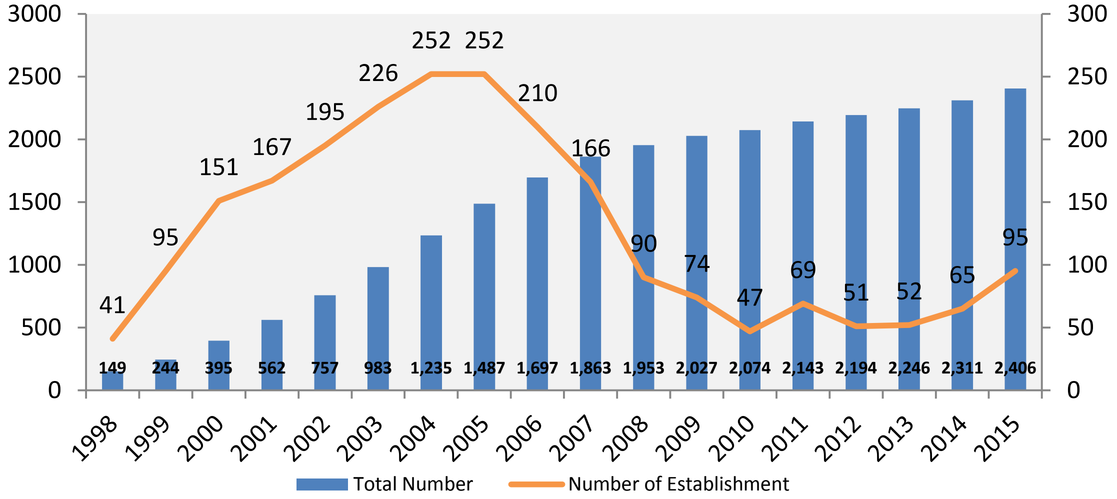


Source: Data collected from MEXT (http://www.mext.go.jp/a_menu/shinkou/sangaku/sangakub.htm)

Note: the licensing income of 2004 includes the revenue from stock sales, and the dotted line represents the number excludes stock sales.

The form of TLO also stimulated the establishment of university startups. Before the promulgation of the TLO Law in 1998, there were no more than 50 companies established by universities each year. In 2001, the Japanese initiated a Hiranuma Plan to set up 1000 start-ups by 2004 to promote economic development (METI, 2001). As shown in figure 6, the establishment of university start-ups stepped up year by year from 1999 to 2005, and had successfully accumulated 1,235 start-ups by the end of 2004. Since 2006, there was a sharp downward trend of annual establishment of start-ups. According to a survey conducted by National Institute of Science and Technology Policy (NISTEP) on university start-ups, reasons for the declining were concluded as 1) Lack of capital supply and business opportunities due to economic recession, 2) Poor management and high risk of start-ups, 3) Lack of national support and support from universities and, 4) Faculties and students were not interested in setting up businesses (NISTEP, 2010).

Figure 7: Evolution of university start-ups (1998-2015)



Source: Data collected from MEXT (http://www.mext.go.jp/a_menu/shinkou/sangaku/sangakub.htm)

3.5 Summary

In this Chapter, I discussed national strategy and government policy in facilitating technology transfer from public institutions through technology transfer organizations. Firstly, I explored Japanese S&T system reform and policy development in the 90s under the background of economic stagnation. In order to revitalize its economy, Japan realized the importance of innovation and adopted the national strategy of "Nation built on the Creation of Science and Technology". Towards that aim, it released a set of national policies to reform the S&T system. The *Science and Technology Basic Law* in 1995 put forward a framework of improving the standard of science and technology in Japan by means of striking a balance of basic research and applied research, nurturing human resources and promoting collaboration among government, academia and industry. The Intellectual Property Strategic Program initiated by the Prime Minister took consistent measures to build Japan into an "IP-based nation". The "*TLO Act*" in 1998 introduced the structure of Technology Licensing Organization to public institutions as an intermediary organization to cycle the knowledge flow between academia and industry in a formal and systematic way. *The Act on Special Measures for Industrial Revitalization* coupled with the *National University Corporation Act* brought fundamental changes to national universities and ownership of research results. National universities were granted autonomy as an independent legal entity to manage the results derived from their researchers, in contrast to being branches of government and had no rights of inventions prior to the reform.

The enactment of the above-mentioned laws has created a favorable legal environment for university-industry cooperation, manifesting by increasing the number of patent-related activities in Japan’s universities, university-industry cooperation projects as well as revenues. TLOs were introduced in 1998 and become the authorized organization of handling university results, which took over 80% of the total number of university patent applications during a period over 1998 to 2013, bringing in increasing licensing revenue and number of start-ups.

Chapter 4: Case studies of national and private science and technology intermediaries

4.1 Introduction

Japan has developed its S&T intermediary system at the national and private level. National S&T intermediaries refer to independent administrative agencies designated to implement government policies and initiated programs to promote technology transfer activities among academia, industry and government, among which the most influential organizations are the Japan Science and Technology Agency (JST) for academia and Small and Medium Enterprise Agency (SME) for industry (Cheng, 2007).

4.2 Japan Science and Technology Agency (JST)

JST is one of the funding agencies attached to MEXT, merged by Research Development Corporation of Japan (JRDC) and Japan Information Center of Science and Technology (JICST) in 1996. Prior to the corporation of national universities, it was responsible for patenting and licensing of all inventions derived from government-fund projects because national universities didn't have independent legal status (Kneller, 2003).

After the reform, JST's mission is to establish an infrastructure for the entire process from the creation of knowledge to the return to society. It has five pillar activities: creating advanced technology (basic research), promoting business using advanced technology (technology transfer), promoting the dissemination of S&T information, researcher exchange and research support, promoting public understanding of science and technology[10]. In this Chapter, I will only mention its efforts in promoting technology transfer from academic institutions.

4.2.1 A-STEP Program

As a major funding agency, JST dedicated itself to fund university-industry collaboration projects. Adaptable and Seamless Technology Transfer Program (A-STEP) is a seamless and integrated bottom-up funding program established in 2009, aiming to boost industry-academia R&D collaborations from early stage to mass production, so that the achievements accomplished by public institutions can be efficiently utilized by the businesses (Nakamura, 2012).

It supports 5 types of projects in three stages (see figure 6):

1) Industrial needs response type (stage 1): In this type, JST selects one or two R&D themes based on the requests from the industry and provides the academic applicants with up to 25 million yen per year. About 10 projects are selected for each theme every year.

2) Strategic theme-focused type (stage 1): In this type, JST selects one or two

[10] For more info as to JST, see http://www.jst.go.jp/EN/jstguide2007.pdf, last visited 3 June, 2019.

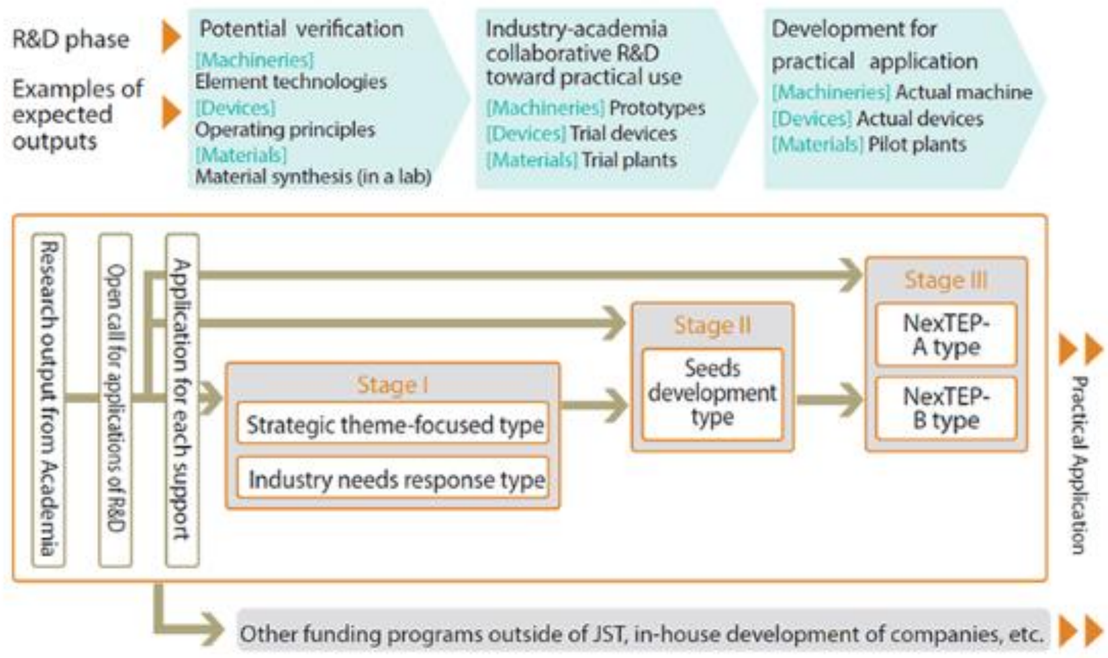
R&D themes based on notable achievements from basic research and calls for the joint application of academia and industry. Up to 50 million yen are provided every year for about five projects in each theme.

3) Seeds development type (stage 2): The type aims to lower the risk of industry-academia collaboration towards practical use. Academia and industry need to apply jointly and the companies are required to provide matching funds equal to 1/4 to 1/3 of the JST funding, which is between 20 million to 500 million yen per R&D period.

4) NexTEP-A type (Stage 3): Stage three projects are designated to support private companies who will carry out the implementation of academic results. In this type, JST provides up to 1.5 billion yen per R&D period. The company need to repay the investing capital by a proportion agreed before plus some of the royalties to JST if it succeeded in industrialization. If they fail, they only need to repay 10% of the total investment.

5) NexTEP-B type (Stage 3): Only small and medium-sized enterprises (SMEs) are funded with up to 300 million per R&D period in this type. There is no repayment obligation in this type, but matching funds and payment of royalties are required if the company completes the project successfully.

Figure 8: Program scheme of A-STEP



Source: JST

4.2.2 Technology transfer support center

Apart from funding of target-driven R&D, JST also has a Technology Transfer Support Center (the "Center"), which is responsible for provide comprehensive support for technology transfer including acquisition of patents, patent enforcement, development of human resources, consultation about technology transfers, university fairs[11].

Regarding intellectual property support, the Center sends "patent investigator" to university TLOs to instruct them to search and acquire patents, form patent strategy consultation, etc. It also offers financial support in the overseas patent application. Apart from that, JST offers training programs to people working in the technology transfer

[11] For more info as to Technology Transfer Support Center, see http://www.jst.go.jp/EN/menu2/02-1.html, last visited 3 June, 2019.

department in universities and TLOs to ensure they have enough knowledge and make a contribution to promote technology transfer. Under the organizing of the Center, about 400 people have attended the Training Program for Specialists of Technology Transfer so far (Miyagawa, 2005). In 2001, it launched a "Coordinator" program to select and assign professional talents to work in technology transfer organizations under government funding. According to a survey conducted by MEXT, over 90% of the universities with "coordinators" thought highly of the system and about 85% of surveyed enterprises believed that the system was necessary (Chen &Han, 2011).

In order to match the "seeds" with "needs", JST established several specialized databases to facilitate disclosure of research results and search for promising companies. JST Science and Technology Research Result Database for Enterprise Development (J-STORE)[12] is a database free-of-charge of research results from universities and public research institutes collected by JST, with the purpose of encouraging technology transfer of these research results to enterprises. The patent information provided in the database covers a wide range of information from Japanese patent (disclosed and undisclosed patent for which less than one and a half years have passed since the application date), international patent, technology seeds information based on patents and abstracts of research reports. In order to facilitate industry partners of evaluating the commercial potential of these results, J-STORE also arranges experts to discern patents from the viewpoint of practical application and described them with diagrams in the function called "Technical eye". Only domestic universities and research institutions

[12] For more info as to JSTORE, see https://jstore.jst.go.jp/aboutJstore.html?lang=en, last visited 3 June, 2019.

can post their available technologies (JST, 2019). It also organizes a national-scale university knowledge fair titled “Innovation Japan” along with New Energy and Industrial Technology Development (NEDO) annually to introduce universities’ technology seeds to the public, which claimed a 10-30% of matching ratio (Nakamura, 2012).

4.3 Technology Licensing Office (TLO)

4.3.1 Introduction of TLO

According to TLO Law enacted in 1998, TLO's main task is to patent the research results of universities and transfer them to companies. The technology developed by the university can be transferred to companies to create new businesses, and a part of the profit can be used for further academic and research funds by returning it to the university and inventor. In this way, TLO plays a role in cycling the knowledge flow between academia and industry[13].

In 2004, University Network for Innovation and Technology Transfer (UNITT) was set up to organize and support technology transfer among universities, research institutes, TLOs by means of promoting IP management, cultivating license associates and conducting surveys to facilitate and supervise industry-academia collaboration. Currently, it includes 69 full members of TLOs and university intellectual property

[13] For more info as to TLO, visit METI’s page https://www.meti.go.jp/policy/innovation_corp/tlo.html, last visited 3 June, 2019.

headquarters[14].

Expected activities of TLOs can be categorized into three phases (see figure 7):

1) Prior to technology transfer: TLOs are responsible for finding, evaluating and selecting the research findings with commercialization potential. Employees of TLOs should reach out to researchers, collect information on research outcomes and evaluate the outcomes based on market needs and feasibility, which requires the staff to have sufficient expertise and market prospects and sensitivity. Apart from building partnerships with universities, it is more important to provide researchers with stable environment for transferring specific research results. The employees need to explore the information or results gathered from researchers based on market needs, the possibility of obtaining patents and feasibility of commercialization before starting filing for patents. After acquiring results with high marketability, TLO will release relevant information to private businesses by means of websites, exchange fair, etc. A membership system can be adopted to give members preferential policy of obtaining information, but at the same time avoid differential treatment for specific private enterprises while providing information. Also, due consideration shall be given to confidentiality of information before disclosure.

2) Transfer of technologies: IP management is the focus of TLOs. TLOs are responsible to patent technological results and negotiate licensing deals with private businesses and assume responsibility of licensing documents to ensure effective implementation of relevant results by enterprises. In return, they extract a proportion of

[14] For more info as to UNITT, visit https://unitt.jp/en/, last visited 3 June, 2019.

royalties as service fees and distribute the rest income to universities and researchers as future research funds based on agreements via donation or other means. Generally, TLOs keep 30% of the income and distribute the rest to universities and inventors (Jia & Pan, 2010).

3) Technology transfer follow-up: After licensing, TLOs continue to provide services to businesses in terms of business management, technical guidance as well as financial support. They advise on tax, accounting, legal affairs and other business management related to startups. They also offer guidance and technical information related to the transferred technologies.

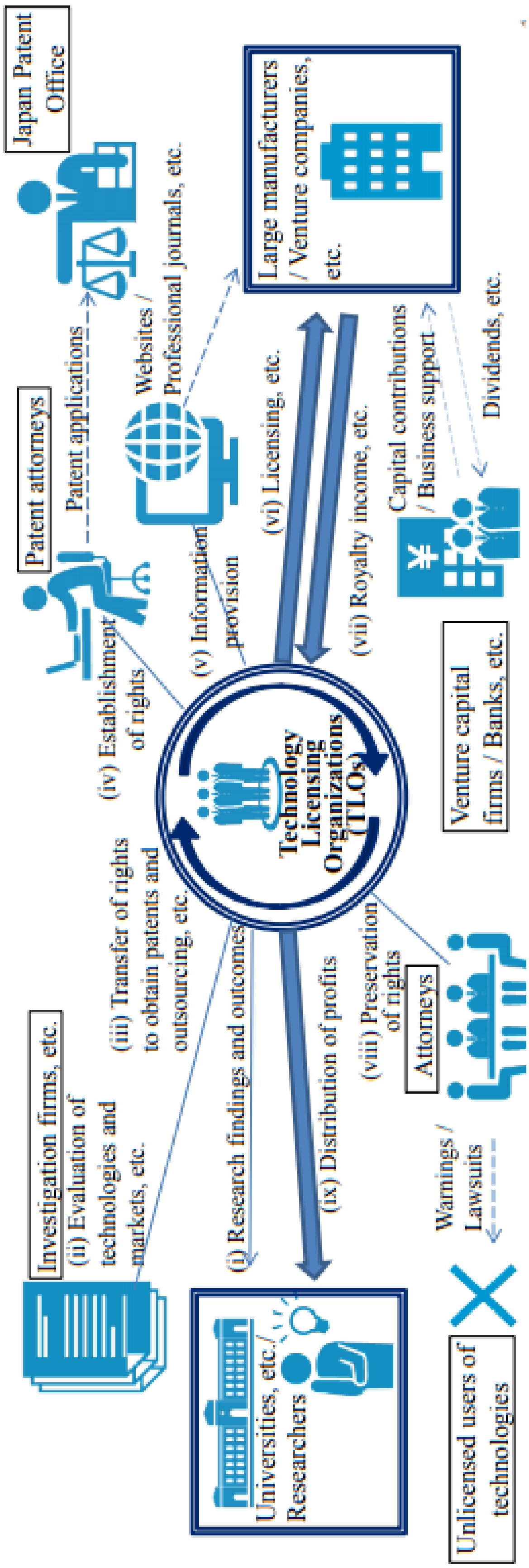


Figure 9: Image of a technology licensing office (TLO)

Source: METI

In general, TLO employees fall into two categories: part-time professors and professional brokers. In most cases, a professor is an expert in a specific field, who can provide professional advice on intellectual property assessments; brokers are responsible for mining scientific research results, evaluation of scientific research results, patent application, scientific research transfer, transfer feedback tracking, etc.(Jia & Pan, 2010).

TLOs in Japan can be launched in the campus or out of the campus as a corporation or limited corporation based on investments from national university researches, or joint venture established by universities and businesses, or as a division of a school corporation in the case of private universities (Takenaka, 2005).

- Internal TLO: This type of TLO is created within the organization using university's funds and facilities, directly managed by the university board or intellectual property headquarters of the university in terms of business management, personnel appointment, income distribution, etc. Internal TLOs have the ideal closeness with the university and stable financial support from the university. However, they lack autonomy in management and the decision-making process is relatively complicated because they are highly subject to the school (Survey on promotion of innovation policy, 2016).

- Internalized TLO：TLO is created as an off-campus institution, while the university internalizes the functions of the external TLO by making it internal and the TLO provides commercialization services to this university exclusively. Compared with internal TLO, internalized TLO is an independent legal entity, meaning it can assume legal responsibilities independently. It receives the university's funding as its shareholder. Therefore, it is managed by the university to a certain extent and at the same time has the autonomy in terms of personal recruitment, project management and income distribution. However, the demerit of this form is that: firstly, it is difficult to conduct integrated collaboration activities with departments related to technology transfer within the university; secondly, since the TLO is market-oriented and need to gain profit for survival, there is concern over this form of TLO patenting research results only base on profitability and overlook that technology will benefit the public but with limited profit (Survey on promotion of innovation policy, 2016)

- Outside TLO: Outside TLOs were established due to the limited patent resources of a single university. In this case, the university collaborates with an external TLO or it establishes one outside the organization and the TLO provides services to neighboring universities within the region. Outside TLOs are the most related to the market, with the widest business scope and highest degree of autonomy. What's more, the division of labor between universities and TLO is clearer. Universities are responsible for the creation, protection and management of intellectual property rights, and TLO is responsible for the marketization of intellectual property rights, etc. On the flipside, it is difficult for them to conduct integrated collaboration activities with university department in terms of university intellectual property. It takes time and resources of communication for technical information, transfer from university to outside TLO (Survey on promotion of innovation policy, 2016). Apart from that, outside TLOs have higher operational risks. Due to the lack of financial support from government and universities, it is completely dependent on the technology licensing fees (Huang, 2010)

TLO's operation income is composed of license income, membership fee, subsidies from the national government, local governments and government agencies, and other service consignment expenses from the universities.

However, the business operation of TLOs has been facing financial challenges. From 2005 to 2008, there was an increasing number of TLOs had deficit problem. For example, 11 (34%) out of 32 internalized and outside Accredited TLOs were in deficit in 2007. And in 2008, 15(45%) out of 33 Accredited TLOs were in the red (Council for Science and Technology Policy, 2010).

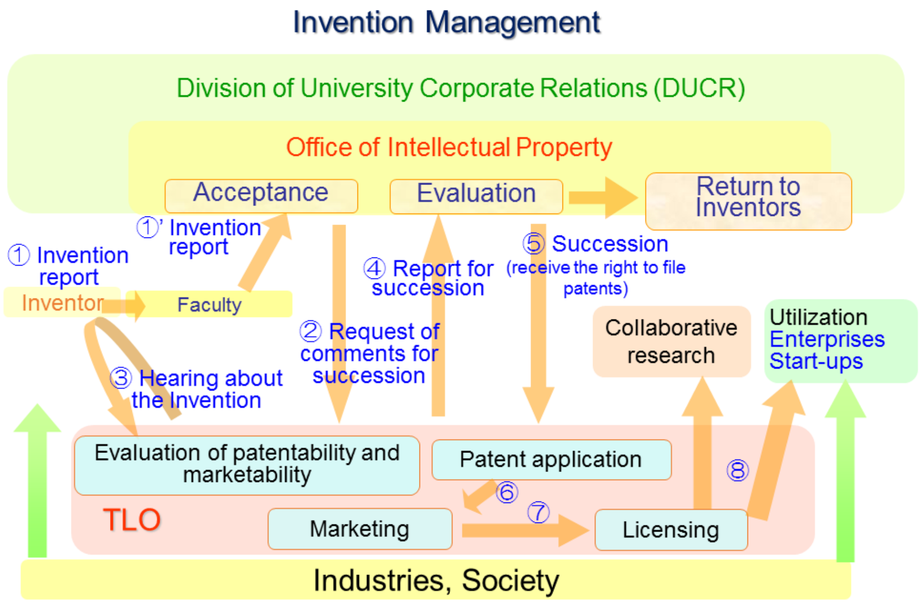
Currently, there remain 35 Accredited TLOs in Japan. In this section, I will focus on discussing the operational model of two model TLOs. One is TODAI TLO of University of Tokyo, which has the most technology transfer revenues and cultivates the most start-up companies; and the other is Kansai TLO, which reverses the deficit management by changing its business strategy (Prónay & Buzás).

4.3.2 TODAI TLO

The TLO of the University of Tokyo is one of the leading examples of technology transfer organizations in Japan (Escoffier, 2015). Todai TLO is an internalized TLO established by faculty members and researchers of the University of Tokyo and one of the four Accredited TLOs approved by METI and MEXT in 1998. To facilitate industry-university cooperation at the University of Tokyo, it has set up a triangle mechanism composed of Division of University Corporate Relations under the direct control of the University's president to manage school IP; TODAI TLO for marketing licenses to businesses and University of Tokyo Edge Capital (UTEC) to support university-oriented start-ups (Yamamoto, 2013). There are about 70 staff altogether, 40 from Division of University Corporate Relations, and the rest 30 from TODAI TLO and UTEC (Fujita, 2007). In 2009, the university acquired 57.5% shares from individual shareholders, thus CASTI became a fully-owned subsidiary of the University of Tokyo, known as TODAI TLO, with a capital of up to 200 million yen (Huang, 2010).

TODAI TLO works closely with the Office of Intellectual Property under the Division of University Corporate Relations in managing university inventions (see figure 8). In the first step, an inventor submits a notice of invention to the Office of Intellectual Property for judging whether the invention is work-related and its marketability and patentability assessment. In the University of Tokyo, the TLO makes the decision on whether to require an assignment from the inventor and go on patent application process. In principal, The Office and TLO need to make the decision within two weeks, otherwise the invention automatically belongs to the inventor after a month (Fujita, 2007). After obtaining royalties and royalties and deducted relevant services fees, 30% goes to the TLO, 30% distributed to the research team and the rest 40% are rewarded to the inventor (Huang, 2010).

Figure 10: Triangle mechanism of technology transfer in the University of Tokyo



Source: Division of University Corporate Relations of the University of Tokyo

One of the characteristics of TODAI TLO is that it has sufficient license revenue to hire professional staff in all stages and fields of invention management. In a 2012-2014 TLO survey, TODAI TLO ranked first with 137 annual average technology licensing cases, followed by Tohoku TLO (117) and Shinshu TLO (105). It is worth noting that the licensing revenue of TODAI TLO accounts for 60% of the total income (Council for Science and Technology Policy, 2010). Most of its licensing associates have university training in science and engineering and industry experience. The license associates also reach out for potential patent through different databases, personal contacts and cold calls (Kneller, 2003).

To figure out the reason why TODAI TLO sustains good momentum of sound development and outstands among all the TLOs after its establishment for more than 20 years ago. Firstly, the key factor is the strength of R&D capabilities of collaboration universities. Backed on its high level of research and development capabilities, the University of Tokyo is said to have been generating more than 500 inventions and 1,600 collaborative research projects each year[15]. The second factor is that it has created an eco-system of technology transfer through the Division of University Corporate Relations. TLO is closely collaborating with internal IP department, which ensures the timely disclosure of the latest inventions. And the high revenue allows it to hire competent staff and offer a high standard of professional services to both inventors and industry counterparts.

4.2.2 Kansai TLO

Kansai TLO was established in October 1998 by several faculty members from Kyoto University, Ritsumeikan Corporation and Daigas Group. In December of the same year, it was recognized as an Accredited TLO by MEXT and METI under the TLO Act. During the first five years after establishment, Kansai TLO performed well with government financial support (Sakai, 2011) However, affected by the IP strategy program and corporation of national universities in 2004, partner university such as Kyoto University, Osaka University, Ritsumeikan University, etc., set up their own Intellectual Property Headquarters, which resulted in decreased workload and revenue. Coupled with the cease of government subsidies after the first five years, Kansai TLO was in deficit for two consecutive years and was faced with the possibility of being shut

[15] For more info as to TODAI TLO , visit http://www.ducr.u-tokyo.ac.jp/en/mission/greeting.html, last visited 4 June, 2019.

down.

The reasons behind the deterioration of management and accumulative deficits are: Firstly, there was lack of standards of judging patentability and marketability of inventions, therefore accumulated large numbers of defective patent assets; secondly, there was no clear division of business among the TLO and IP Headquarters of each university. As a result, there was duplication of duties and two parties were unable to collaborate in technology transfer activities; and thirdly, Kansai TLO outsourced all marketing activities to 20 part-time employees and its own full-time employees only take the responsible of managing external associates, this business model aroused dissatisfaction from the businesses and lost its reputation in this industry (Sakai, 2011).

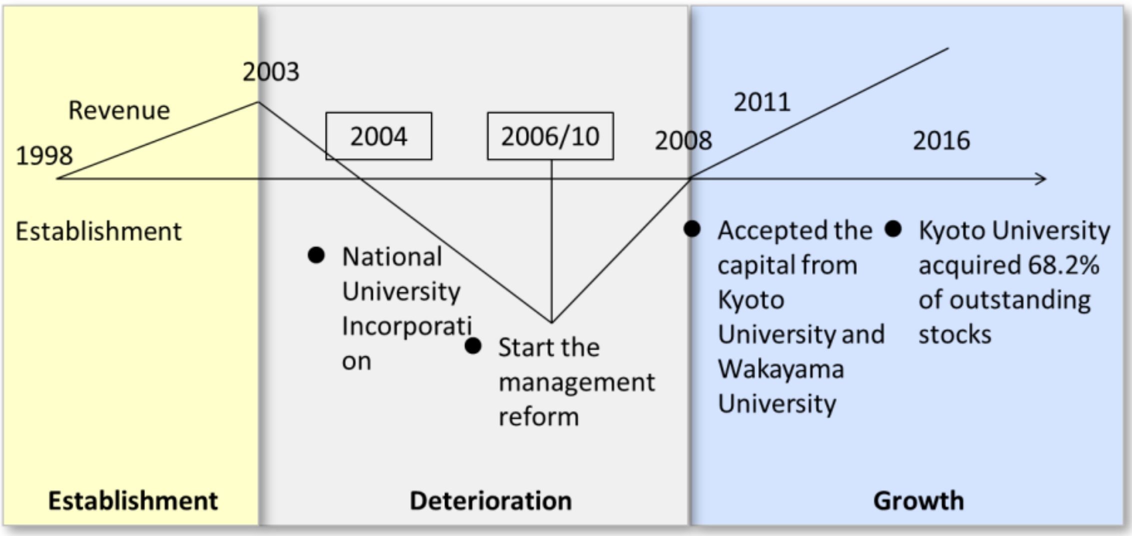
Thanks to the strong support from Ritsumeikan Corporation, the second largest shareholder, Kansai TLO started to rebuild itself into an outside TLO collaborating with several universities by means of business entrustment contracts. Kansai TLO is responsible for conducting exclusive surveys and evaluations for intellectual property of each university. Up to now, it has established partnership with Kyushu University, Wakayama University, Kyoto Prefectural University of Medicine, Fukuoka University, Nagoya Institute of Technology and Ritsumeikan University[16].

To deal with the former problems, it made several reforms in the management. Firstly, it changed the personnel system. As mentioned before, Kansai TLO used to outsource its patent management services to part-time employees. However, it was not able to accumulate specialized information such as company needs successful or failure

[16] For more info as to Kansai TLO, visit https://www.kansai-tlo.co.jp/english/, last visited 10 June, 2019.

experiences within the TLO. To tackle this problem, Kansai TLO shifted from outsourcing to employing full-time employees of conducting IP related activities. It also adopted programs for nurturing young associates and Human resources development for young associates and encourage staff to work as a team. Another major reform is to re-establish relationship with university's intellectual property headquarters. The duties of two parties were clarified as IP headquarters of each university in charge of managing intellectual property, while Kansai TLO in charge of evaluation of inventions and marketing them to the industry.

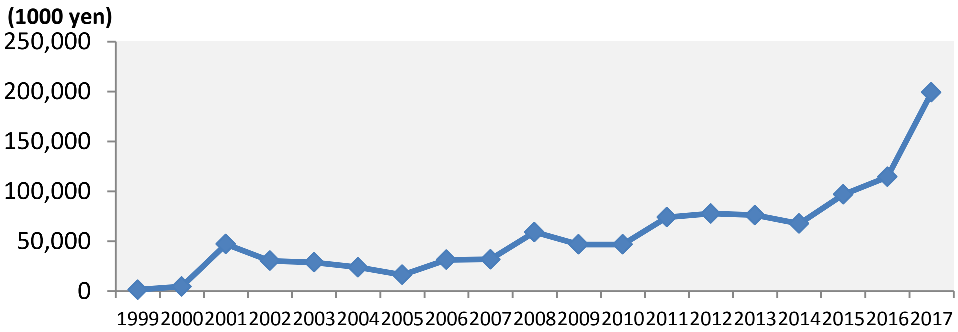
Figure 11: Evolution of development of Kansai TLO



Source: Recompose of the diagram made by Sakai (2011)

As shown in figure, since the completion of management reform in 2008, licensing revenue has been gradually increasing. In 2010, Kyoto University made a big leap in the ranking from the 20th to the 4th in the "Academic-University Cooperation Survey on Performance of Intellectual Property Rights Management". Licensing revenue rose from 16500 thousand yen in 2005 to 74073 thousand yen in 2011 and has been able to record a continuous operating surplus till now (see figure 10). Kansai TLO chose to conduct management reform during the most difficult period, and managed to make a transition to a leading outside TLO.

Figure 12: Transition of licensing revenue in Kansai TLO



Source: Data collected from Kansai TLO

There are a few lessons can be learnt from Kansai TLO's development: firstly, coordination and clarification of the relationship between TLO with institution's IP department are important of forming sustainable partnership; Secondly, expanding business scope and cooperating with several universities is a good choice of sustaining business opportunities and integrating resources to build brand image; thirdly, development of human resources and strengthening teamwork are lasting driver to the sustainable development of TLOs.

4.4 Summary

In this Chapter, I discussed operation mechanism of national and private S&T intermediaries on policy implementation level to facilitate technology transfer from public institutions. I explored the function of JST, the national S&T intermediary and private TLOs. In the case of JST, I examined its gap funding program named “A-STEP”, which offers funding to both academia and industry to develop market-oriented technologies at various stages from feasibility study to pilot application. It encourages early-stage collaboration between academia and industry and provides guarantee and resume major risks of commercialization of national projects. Apart from project funding, JST also provides IP related services to private S&T intermediaries or TLOs. The “Technology Transfer Support Center” assists TLOs through technical consulting and human capital building. Moreover, it contributes to the establish of nationwide technology diffusion network which allows technology supplier, the academia and technology demander, the businesses to search for each other by means of its specialized databases and forge a match though face-to-face technology presentation and university fair activities.

In the case of TLOs, I have explored two typical TLO cases, TODAI TLO and Kansai TLO among the current existing 35 organizations. The two organizations are among the first batch of Accredited TLOs recognized by MEXT and METI right after the promulgation of TLO Act in 1998 and developed distinctive business models to withstand market competition. Backed by strong academic competence of Tokyo University, TODAI TLO is streets ahead of other TLOs in terms of licensing revenue and number of university-based startups. The triangle mechanism composed of Division of University Corporate Relations (IP management); TODAI TLO (IP marketing) and UTEC (university-oriented start-ups support) guarantees the smooth transition of research results from the inventors to the market. The development of Kansai TLO has undergone ups and downs. After the cease of government subsidies of the first five yeas' operation and coupled with the reform of legal status of national universities, Kansai TLO was in a difficult time faced with the deterioration of management and accumulative deficits. It reformed the business model and rebuilt itself into an outside TLO collaborating with several universities. At the same time, internal changes focusing on the rising standard of IP evaluation, collaborative relationships with IP departments within universities and capacity building of full-time employees were initiated, which helped Kansai TLO got out of financial trouble and began to make a profit again. The two models are worthy of learning by other TLOs in order to achieve sustainable and sound development.

Chapter 5: Analysis and policy recommendation

This research is to explore factors that contribute to the establishment and sound development of S&T intermediaries in Japan. The key point of science and technology policy is that government uses its political and economic power to develop technology into real productivity (Wu, 1998). It can be concluded from the analysis that Japanese government created an infrastructure for the establishment and development of S&T intermediaries in which various shareholders in technology transfer system can be linked and interact with each other.

5.1 Characteristics of Japanese S&T intermediaries' development

5.1.1 Sophisticated laws and regulations

Firstly, the study shows government policies laid a solid foundation for the construction of technology transfer system from universities to businesses in Japan. In terms of legal support of technology transfer system, the establishment of *Science and Technology Basic Law* in 1995 set up the fundamental principal of S&T system reform in Japan, greater emphasis was given to the development of indigenous science and technology at an unprecedented level by setting the strategic goal of building a nation based on creation of science and technology. The Japanese government was required to formulate basic plans for revitalizing science and technology, and formulate supporting measures to ensure the smooth implementation of basic plan. As the top-level design of Japan's science and technology system, the Basic Law clarifies the rights, responsibilities and interests of different administrative departments and leads them towards the same goal of revitalizing the economy base on innovation. In the first Basic Plan, the emphasis was given to the increase of government spending on R&D and promotion of collaboration among government, university and industry. To that end, a series of policies were introduced to strengthen the relationships between university and industry. Moreover, the establishment of the Council for Science and Technology Policy integrates leadership in government, academia and industry to formulate national strategies based on coordination among various departments, so that each shareholder's interest is taken into account. The structure of S&T intermediaries was introduced by the government as a tool to formalize the knowledge transfer between academia and industry.

The Japanese government attaches great importance to the role of intermediaries in connecting different shareholders of technology transfer and supports its development by creating a favorable legal environment to ensure its legal status and at the same time clear institutional barriers for its development. For example, the *TLO Act* is the legal basis for the establishment of Technology Licensing Organizations as an intermediary organization created by universities to manage intellectual properties in a formal and professional way. The TLO system changed the informal pattern of technology transfer between university researchers and businesses and forged a formal relationship by means of the specialization organization, which resulted in a sharp increase in university technology transfer activities. To support TLO's establishment and development, the government offers supporting regulations in terms of financial subsidies for the first few years and human resources. For example, grants of up to a maximum of 30 million yen for the first five years of operation from MEXT, debt guarantees from the Organization for Small & Medium Enterprises and Regional Innovation, exemption of patent registration fees for the first to the tenth year and reduction of patent maintenance fees for Intellectual Property Headquarters.

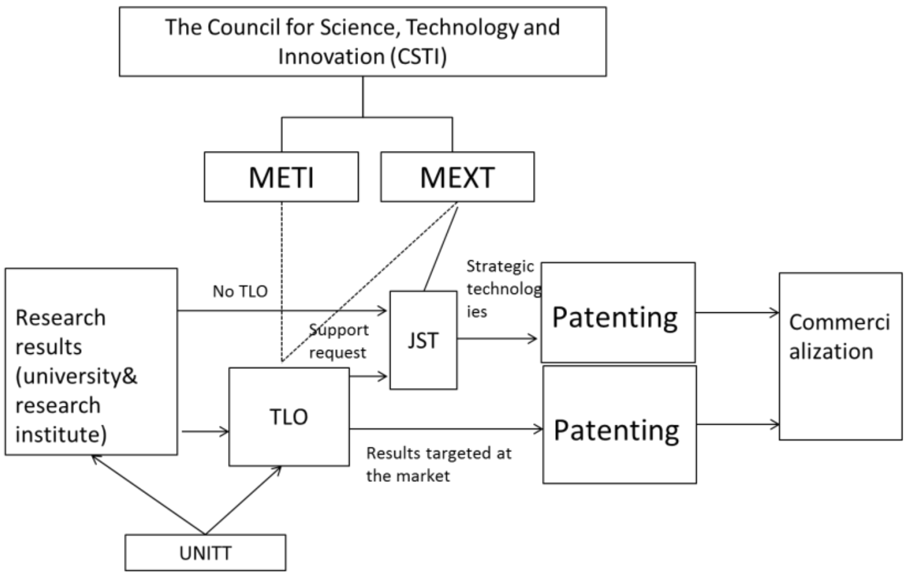
Followed by the introduction of TLO structure, the Japanese government formulated supporting policies to remove barriers that hindered the technology transfer of public institutes through the operation of TLOs. *The Act on Special Measures for Industrial Revitalization* transformed the ownership of government-funded projects from state-owned to university-owned. However, this law only benefited private universities at first because national universities were government organizations at that time and didn't have legal status to own patents. This situation changed after the privatization of national universities in 2004. The release of *National University Corporation Act* gave national universities legal status as "Incorporated Administrative Agency", which meant universities were entitled to manage the intellectual property by setting up TLOs. It also deregulated faculty staff of the National Universities and allowed them to take part-time posts at TLOs. Thus, the reform of the National University in 2004 into independent administrative legal entity qualified and motivated universities to engage in technology transfer activities, and also promoted the establishment of TLOs.

5.1.2 National guidance

Secondly, the study shows Japan has formed national governance of technology transfer system composed of different types of S&T intermediaries from a holistic and professional perspective (see figure 11). MEXT and METI are two government ministries responsible for the development of national education and industrial respectively. The two ministries are collaborating in implementing basic plans stipulated by CSTI, one of which is to instruct national and private S&T intermediaries in promoting academia-industry partnerships. Attached to MEXT, Japan Science and Technology Agency (JST), a national-level independent administrative agency, operates as a national intermediary organization to manage the country's overall technology transfer activities from a strategic and long-term perspective in the entire process of technology transfer, ranging from funding market-oriented basic research, assisting technology transfer activities in TLOs to infrastructure construction of S&T information dissemination databases, researcher exchange, etc. Approved and incentivized by both Ministries, TLOs are responsible for technology transfer from an individual universities or a cluster of universities. Besides, an industry association, the University Network for Innovation and Technology Transfer (UNITT), whose members are universities, research institutes and TLOs, is dedicated to the promotion of communications among member organizations and nurturing technology transfer experts. In the implementation level, although government doesn't engage in the management of S&T intermediaries, they support S&T intermediaries financially to conduct technology transfer business. For JST, the enterprise shall repay the sales income to JST as operation fund if technology transfer projects go well; if not, the fund doesn't need to be returned and will be paid by national special funds. For TLOs, they are self-financing in accordance with market principles. At the same time, they are entitled to receive preferential policies from different ministries.

National organizations have overarching guidance on the establishment and performance of subordinate organizations and provide various kinds of support in terms of funding, technical assistance, infrastructure facility, manpower, etc. to ensure the sustainable development of each intermediary.

Figure 13: Structure of technology transfer system in Japan



Source: Recompose of diagram made by JST

5.1.3 Market-oriented model

Another point needs to be mention is the market-oriented operation model of S&T intermediaries in Japan. The ultimate goal of technology transfer is to apply inventions into application. Therefore, a market-oriented mindset is applied throughout the entire process from knowledge creation, management and dissemination of S&T intermediaries. For example, IP Headquarters are established within the Cabinet and most of universities to plan IP strategy based on the analysis of market needs and explore inventions with high marketability. The enhancement of market-oriented IPs is a prerequisite for follow-up technology transfer activities. As can be seen from the previous discussion, IP evaluation on patent's marketability and patentability from licensing associates is the first step and decides whether TLO will start the licensing process. TLOs have raised a high standard of patentability and marketability evaluation to ensure higher possibilities of licensing to businesses, otherwise, they would end up with a large accumulated defective patent assets, as the case Kansai TLO encountered, which might lead to deterioration of management of a TLO. This is because TLOs in Japan are established in the campus or out of the campus as a corporation or limited corporation, although they can receive government subsidies, those subsidies have a time limit. Therefore, TLOs are self-financing and need to be profitable. For those achievements with lower marketability, researchers are encouraged to continue experimenting, and for those technological achievements with certain market prospects; TLO encourages researchers to joint hands with industrial partners to conduct pilot tests; and for those achievements with high potential of industrialization, TLOs market them to the industries as brokers and distribute part of the profit to the university and inventor after successful licensing.

5.1.4 Information transparency

Besides, information sharing network is well established in technology transfer system by means of free databases, national university fairs and other forms of exchanges of people. In light of JST was formed with the merged of Research Development Corporation of Japan (JRDC) and Japan Information Center of Science and Technology (JICST), it is equipped with abundant information and resources from academia and industry. It has established several specialized databases to avoid information asymmetry of technology supply and demand end. For example, J-STORE is a free-of-charge database to disseminate both disclosed and undisclosed patents from universities and public research institutes, with evaluation reports from experts on the commercial potential of these results.

5.1.5 Talent development

Last but not least, development of human resources is high on the agenda of national strategy as well as TLO management. Nationally, *the Science and Technology Basic Law* put personnel exchanges among different technology transfer sectors as a key promoting area. In implementation level, IP management advisors are dispatched to universities and public research institutes from IP Headquarters. JST also takes the responsibility of organizing training and personnel exchange programs to instruct TLO staff to better their competence and performance.

TLOs also attach great importance to attract and nurture interdisciplinary talents who are familiar with technology, market and finance areas. For example, TODAI TLO is committed to hiring competent staff and most of its licensing associates have university training in science and engineering and industry experience. Struggle with financial deficit, one of the major reforms Kansai TLO adopted is to end outsourcing and start employing full-time employees while nurturing young associates.

5.2 Features of Chinese S&T intermediaries' development

5.2.1 Major Legislation

In 1985, the release of *Decision of the Central Committee of the Communist Party of China on the Reform of the Science and Technology System*[17] marketed the beginning of reform on science and technology system, in which the goal of invigorating economy based on science and technology was put up and cooperation among industries, universities and research institutes were highlighted to promote industrialization of public research results (OECD, 2008).

In 1996, the Ministry of Science and Technology issued *the Law on Promoting the Transformation of Scientific and Technological Achievements*, which became the basic law on technology transfer.

In 2002, the Ministry of Science and Technology released *the Opinions on vigorously developing technology intermediaries*[18], in which it set up six principles for

[17] For more info visit http://www.gov.cn/zhengce/content/2016-10/19/content_5121808.htm (in Chinese), last visited 4 June, 2019.
[18] For more info visit http://www.most.gov.cn/fggw/zfwj/zfwj2002/200512/t20051214_54981.htm (in Chinese), last visited 4 June, 2019.

accelerating the development of S&T intermediaries, including the combination of government interference according to market demand, standardized operation in development, classification of different types of science and technology intermediaries, network collaboration, etc.

In 2006, *National Long- and Medium-Term Plan for Science and Technology Development (2006-2020)* incorporated S&T intermediaries as an important player into national innovation systems, and put forward the goal of building a socialized and networked technology intermediary service system with multiple functions by 2020.

In 2016, *Law on Promoting the Transformation of Scientific and Technological Achievements*[19] was revised, which Increased incentives from 20% to 50% of net income reward to inventors. Besides, Universities and research institutes can independently transfer, license or invest in the results they hold.

The above-mentioned policies have shown that Chinese government has attached great importance to technological innovation and the transformation of scientific and technological achievements since a long time ago. S&T system is still in the process of reform and the importance of S&T intermediary is gradually recognized by the government.

5.2.2 Development of S&T intermediaries

In 2001, the state promulgated the "Notice on the Establishment of National Technology Transfer Centers in Some Universities", which approved six universities to

[19] For more info visit http://www.lawinfochina.com/display.aspx?id=19886&lib=law, last visited 4 June, 2019.

establish national technology transfer centers. The six technology transfer centers signed 2,922 contracts with contract amount of 824 million yuan in 2002 (He, 2008). After the release of Opinions on vigorously developing technology intermediaries in 2002, more and more universities and research institutes start to establish S&T intermediaries in the forms of University Science Parks, Technology Transfer Centers, etc. (Li, 2012).

The Ministry of Science and Technology untrusted its Torch High Technology Industry Development Center to conduct identification of national S&T intermediaries in 2006, in an effort to standardizing various types of technology intermediaries and enhance the service quality and competition awareness of technology transfer institutions. The identified organizations are entitled to enjoy tax incentives[20].

Table 2: Policy documents of national technology transfer institutions

Time	Policy Documents	Description
2006	Identification and Management Measures on National University Science Parks (NUSP)	Exempt from business tax, income tax, property tax and urban land use tax within a certain period from the date of recognition.
2007	Management Measures on National Technology Transfer Centers (NTTC)	1. Government policy support in financial, taxation, talent and other aspects. 2. Incorporate the management of National Technology Transfer Centers into national innovation environment and industrialization construction by allocating special funds in national science and technology plan to subsidize their construction.

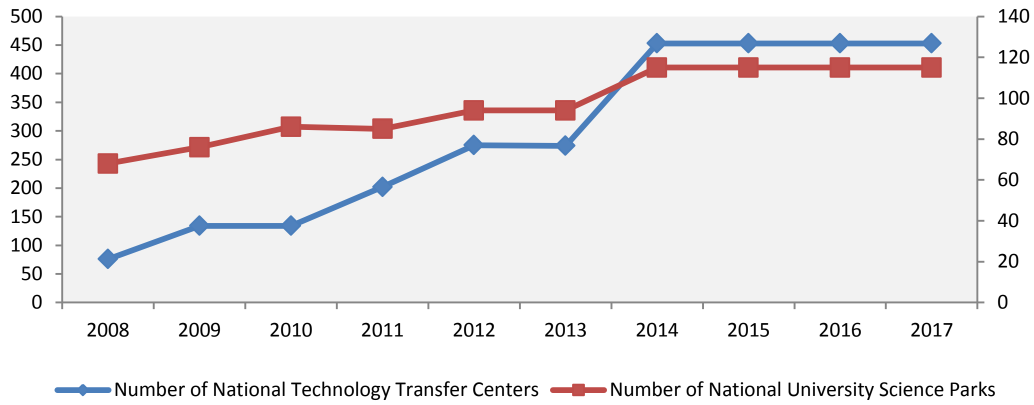
Source: Information collected from the website of Torch High Technology Industry Development Center.

Stipulated by national and local support policies and market demand, China's science and technology intermediaries grow rapidly in numbers. By the end of 2017, the

[20] For more info about Torch High Technology Industry Development Center, visit http://www.chinatorch.gov.cn/english/index.shtml, last visited 4 June, 2019.

number of national NTTC rose from 76 in 2008 to 453 in 2017, nearly 5 times increase. The number of NUSP nearly doubled the size in 2008 and reached 115 (Torch High Technology Industry Development Center, 2018).

Figure 14: Transition Trend of National S&T intermediaries in China



Source: Data collected from website of Torch High Technology Industry Development Center

5.2.3 Characteristics of Chinese S&T intermediaries

The statistics of *Compilation of Science and Technology Statistics of Higher Education in 2016* showed that research funds entrusted by enterprises in China's universities reached 41.373 billion yuan in 2015, while the total revenue of technology transfer contracts were only 2.341 billion yuan; patent applications reached 184,423, among which 12,1981(66%) were granted. However, only 2,695 patents were licensed to businesses, accounting for 3% of the grant patents (Department of Science and Technology, 2016). The statistics indicated that more efforts need to shield to the development of technology transfer system in China. China's S&T intermediary service started in the late 1980s and is still in its infancy compared to developed countries.

5.2.3.1 Branches of institutional department with no legal status

Wu (2016) investigated 296 NTTCs and found that 121 of them were subordinate to government, among which 100 (82.6%) were institutions without legal status and 21 had the status as enterprises; 76 of them were established by research institutes, among which 40 (52.6%) were branches within the institutes and 36 collaborated with enterprises; 58 of them were established by universities, among which 44 (75.9%) were university administrative departments, only 14 were companies. The survey reveals that over 40% of NTTCs are established by the government, 25.6% are of research institutes and 19.6% are of universities, and more than half of the NTTCs established by research institutes and more than 75% of NTTCs established by universities are branches of respective administrative departments with no legal status. Among the investigated 296 NTTCs, 71 organizations were operated as companies, accounting for 24% of the total number. These data show a majority of S&T intermediaries in China exist as branches of governments, research institutes and universities, with no legal status and a strong adherence to government and institutional support. What's more, the daily workload of administration departments in China are burdensome and the salary of administrative staff are fixed in accordance with his or her post level, which means they are not motivated to promote technology transfer from the organizations (Shen, 2016).

5.2.3.2 Limited national guidance and supporting measures

There is no specific fund or program at the national level to support science and technology intermediaries financially; however, they are among the supporting lists in relevant national science and technology programs (Liu, 2013). For example, China Torch Program, a plan initiated by Ministry of Science and Technology to facilitate the combination of industry and technology by the market system, allocates funding to support science and technology intermediaries under industrial environment construction project. Miesing (2017) surveyed seven Western China technology transfer institutions and compared them with Technology Transfer Institutions. He concluded that China established its S&T intermediaries on a regional level, while most western countries set up their technology transfer systems on the national level. The Torch Center under MOST is in lack of any overarching guidance on various S&T intermediary institutions at the national level.

5.2.3.3 Shortage of talents

Li (2011) conducted a survey on the development of S&T intermediaries in Yangtze River Delta, which has the most developed S&T intermediary system because of the geographic location. The survey was conducted by mailing questionnaires and interviews. The results showed that only 8.87% of the surveyed employees obtained the certificate of broker issued by the Ministry of Science and Technology. Take Shenzhen as an example, less than 400 people were licensed in 1,200 technology intermediaries. After evaluating the working efficiency, Li (2012) pointed out that management staff in universities and public institutes do not have enough knowledge in terms of market, business and negotiation, which are of vital importance to successful technology transfers.

5.3 Policy recommendations for China

From the policy analysis, Japan and China both attach great importance to S&T innovation and technology transfer from academia institutions, along with the formulation of a number of government policies to construct its technology transfer system. However, China is still in the process of deepening the reform of S&T system. In 2012, the state started a new round of S&T system reform with the release of "*Opinions on Deepening the Reform of the Scientific and Technological System and Speeding up the Building of a National Innovation System*"[21]. The opinion pointed out current problems in China's S&T system, featuring collaboration among enterprises, universities, and research institutes remain weak; low rates in the commercialization of research results, technology and economy are yet to be truly integrated, etc. and put forward the objective of building a market-oriented system for technological innovation. As an important intermediary player in the national innovation system, S&T intermediaries are faced with both opportunities and challenges. Based on Japan's experience of introducing and developing S&T intermediaries into its S&T system, this paper proposes the following policy recommendations:

[21] For more info, see https://www.most.gov.cn/eng/pressroom/201211/t20121119_98014.htm, last visited 6 June, 2019.

5.3.1 Establishing a specialized national organization

Although S&T intermediaries shall be integrated into the market economy, the government shall not let it develop freely. Learning from Japan's experience, the first policy recommendation to Chinese's policy-makers is to establish a national intermediary organization to guide, assist and monitor the development of various S&T intermediaries. A national institution can better implement government policies and make strategic plans of overall development of intermediary system from a holistic perspective. Currently, there is a Torch Center, which is subsidiary to the Ministry of Science and Technology (MOST), to guide the overall development of high-tech industries in China (Torch Center, 19). Regarding guidance and support to S&T intermediaries of public institutions, Torch Center started the identification of state-level NUSP and NTTC since 2006 and has been allocating special funds for state-level intermediaries from its sub-programs, in an effort to create a proper environment for the industry development. The scope of guidance and support to intermediaries is limited if compared with Japan, who has a specialized national organization JST to provide overarching guidance of university-industry linkage in terms of funding, technology transfer consulting, infrastructure and manpower support, etc. Thus, it is suggested that China establish a specialized national organization with the mission to:

- Make overall plans to implement government policies regarding academia-industry technology transfer;

- Reform the holistic management system of technology transfer from public institutions;

- Create a favorable market and policy environment for the development of S&T intermediaries;

- Construct infrastructure for resources sharing and information transparency;

- Promote the sharing of national technical information, knowledge and talent resources.

5.3.2 Adopting market-oriented development model

Different from Japan's market economy system, China's S&T system went through the transition from a centrally planned system to a socialist market economic system, which explains the situation of high percentage of S&T intermediaries are in the control or subordinate to government organizations and public research institutions.

This round of S&T reform will pose serious challenges to S&T intermediaries set up by public institutions as those institutions highly depend on government or institutional funding before, thus they lack the experience of operating in a free market.

Learnt from Japan's experience, a certain number of TLOs were faced with difficulty in self-sufficient management, especially after the cease of government subsidies after the first five years of their establishment, which led to the cancellation of those with financial deficit. Thus, business management is crucial for the sustainable development of TLOs. Based on the case study of TODAI TLO and Kansai TLO, the recommend development modes are as follows:

For institutions of strong scientific and technological capabilities that can sustain a long-term and high-quality output of research results, it is recommended to adopt the model of TODAI TLO and establish their technology transfer organizations in the campus or out of the campus as a corporation or limited corporation. The organization is responsible for evaluating and commercializing research results from the funding institutions, with autonomy of its management operation.

For other institutions, it is recommended to adopt the Kansai TLO model and establish intermediaries by joint forces. This approach is effective in integrating regional resources to sustain results supply, which is beneficial to the long-term development of intermediaries, as shown by the case of Kansai TLO. For both types, it should be noted that coordination and clarification of the relationship between TLO with institution's IP department are of great importance in forming a sustainable partnership. In the meanwhile, the development of human resources and strengthening teamwork are lasting driver to the sustainable development of TLOs.

5.3.3 Enhancing supporting measures for S&T intermediaries' development

The studies of Japan's technology transfer policies shown that in order to facilitate academia-industry technology transfer, the Japanese government has issued a set of supporting policies in areas of science and technology development, intellectual property management, industrial revitalization and university privatization, which involved every shareholder ranging from government, universities, industries to TLOs. All these policies helped to remove the obstacles of TLO's development and incentivize its sustainable development. In light of China's relatively short history of market economy development, the development of S&T intermediaries needs intensive measures of macro adjustment and control by the government (Zhao & Wan, 2008). The Chinese government is suggested to introduce more favorable policies for the independent development of S&T intermediaries:

- Increase financial support: Arrange special fund to alleviate the financial pressure of S&T intermediaries, especially the initial stage of establishment. Learning from the Japanese context, the Chinese government can consider providing subsidies for the first few years of establishment as well as guarantees for the issuance of corporate bonds or bank loans by intermediaries. In the meanwhile, preferential policies related to patent applications and maintenance is also recommended. It is worth noting that all the supporting policies shall specify the object, term and scope as well as be consistent with other relevant policies.

- Promote talent cultivation: Government shall establish mechanisms for talent certification, training and flow among different organizations.

- Initiate information sharing network: In order to promote information flow among various intermediaries, government shall take the lead in constructing information sharing network at both regional and national levels, which involves hardware construction such as specialized databases of academia results and university fairs or workshops attended by university and industry counterparts.

Based on the lessons learned from Japan’s experience, guidance of business management for TLOs and university start-ups is also recommended in order to achieve sustainable development. The declining number of Accredited TLOs and university start-ups in Japan shows that government support can stimulate organizations’ short-term growth. Despite the overall economic climate, suitable business model and management is crucial for an organization to withstand the fierce market competition in the long run, and that’s where the government shall pay due attention to.

Chapter 6: Conclusion

Japan and China both attach great importance to S&T innovation and technology transfer from academia institutions The Chinese government is gaining momentum to promote S&T intermediary industry by putting forward the goal of building a socialized and networked S&T intermediary system towards specialization, large scale and standardization in its *National Medium-and Long-term Program for Science and Technology Development (2006-2020).*

Japan was the first country achieved industrial success based on science and technology in non-European region. It has developed S&T intermediary industry to cycle the knowledge flow between academia and industry based on a set of sophisticated legislations, which offer a favorable legal environment to S&T intermediaries. As to policy implementation, national S&T intermediary, JST, manages the country's overall technology transfer activities from a holistic and long-term perspective by means of funding research projects, guiding TLOs, constructing network infrastructure as well as manpower development, while private S&T intermediaries, TLOs, have developed into different forms to withstand market competition. Common practice of TLOs is to apply a market-oriented mindset throughout the entire process from knowledge discovery, management and dissemination, coordinate and clarify the relationship with institution's IP department and prioritize internal human resources development.

As concluded from Japanese case studies, the successful factors of Japanese S&T intermediaries include sophisticated laws and regulations, national guidance, market-oriented model, transparent information network and emphasis on talent development. Considering China is still in the process of deepening the reform of S&T system and S&T intermediary service is still in its infancy, tentative policy recommendation for China is to establish a specialized national organization to guide, assist and monitor the development of various S&T intermediaries, operate S&T intermediaries with market-oriented model and enhance supporting measures in terms of incentives, talent cultivation and information sharing network.

Constrained by time and efforts, this report didn’t collect data and information on Japanese S&T intermediaries through interview or survey with organization insiders, which would have provided more detailed and practical information of operation mechanism of Japan’s S&T intermediaries. Moreover, this report only covers Japan, while other technology-advanced countries such as the United States, Germany, etc. may also have good practice in building its S&T intermediary industry. Further study is suggested to investigate deeper about the operation mechanism of different organizations and cover a wider scope of countries.

S&T intermediaries are an important player in the national innovation system. It is hoped that this research report can provide a rational train of thought for Chinese policy-makers in formulating new policies on the development of S&T intermediaries, as well as for leaderships in Chinese public institutions in constructing and operating of S&T intermediaries.

References

Angelino, H., Collier, N. (2004). Comparison of innovation policy and transfer of technology from public institutions in Japan. France, Germany and the United Kingdom. *NII journal*, *8*, 53-90.

Arai, H. (2005). Intellectual property strategy in Japan. *International Journal of Intellectual Property-Law, Economy and Management*, *1(1)*, 5-12.

Barratt, A. (2010). Lessons from Bayh-Dole: Reflections on the intellectual property rights from publicly financed research and development act. *Journal for Juridical Science, 35(2),* 30-69.

Bi, H.Y. (2006). The function of government in university technology transfer(政府在大学技术转移中的职能定位). *Science and Technology Management Research, 1,* 17-20.

Bozeman, B. (2000). Technology transfer and public policy: a review of research and theory. *Research policy*, *29(4-5),* 627-655.

Chen, H.Q., Han, S.M. (2011). Technological achievements transformation and intermediary organizations construction: The experience of industry-university-government collaboration in Japan (科技成果转化与中介组织建设：日本产学官合作的经验与借鉴). *2011 International Conference on Engineering and Business Management*.

Cheng, Y.M. (2007). The operation mechanism of Japanese science and technology intermediary organizations (日本科技中介机构的运行机制及其启示). *Japanese research*, *1*, 50.

Clark, B. (2001). The entrepreneurial university: New foundations for collegiality, autonomy, and achievement. *Higher Education Management*, *13(2)*, 56-60.

Council for Science and Technology Policy. (2010). Retrieved 5 June, 2019 from http://www.mext.go.jp/b_menu/shingi/gijyutu/gijyutu8/011/gijiroku/__icsFiles/afieldfile/2010/07/23/1294844_5.pdf.

Debackere, K., Veugelers, R. (2005). The role of academic technology transfer organizations in improving industry science links. *Research policy*, *34(3)*, 321-342.

Escoffier, L. (2015). Japan's Technology Transfer System: Challenges and Opportunities for European SMEs. *EU-Japan Centre for Industrial Cooperation*, 66.

Fujisue, K. (1998). Promotion of academia-industry cooperation in Japan—establishing the "law of promoting technology transfer from university to industry" in Japan. *Technovation, 18(6-7),* 371-381.

Fujita, T (2007). Keynote speech of R & D Symposium on collaboration with industry from the perspective of the university: focusing on the case of the University of Tokyo (R&D シンポジウム 基調講演 大学側から見た産業界との連携--東京大学の事例を中心として). *Technical review, JR East*, *19*, 2-9.

Fukasaku, Y., Ishizaka, S. (2010). Science and technology policy in Japan. *Social and economic development, 3*, 101.

Gao, L.N., Gao, S.J. (2012). The study of Sci-tech achievements transformation function of the sci-tech intermediary institutions (科技中介机构的科技成果转化功能探讨). *Reformation & Strategy, 5 (28)*, 176.

Gu, J.G. (2006). Give full play to the role of science and technology intermediary in China's innovation systems (发挥科技中介在我国创新体系中的作用). *Journal of Xi'an Jiaotong University, 26(6)*, 34-39.

Guo, X.H., Li, Z.F. (2014). Research on role evolution and policy selection of Science and technology intermediary from the perspective of open innovation (从开放式创新看科技中介机构角色演变及政策选择). *Scientific Management Research, 32 (3)*, 5-8.

Han, Z.H., Li, G.P., Chen, L.H. (2004). The construction of Japanese technology transfer institution (TLO) and its enlightenment to China(日本技术转移机构(TLO) 的营建及对我国的启示). *Contemporary economy of Japan, 5*, 53-57.

Hasegawa, K., Sugawara, T. (2017). Characteristics of university startups in Japan. In *2017 IEEE Technology & Engineering Management Conference (TEMSCON)*, 67-72.

Harayama, Y. (2001). Japanese technology policy: history and a new perspective. *Research Institute of Economy, Trade and Industry*, 33.

Hellmann, T. (2007). The role of patents for bridging the science to market gap. *Journal of Economic Behavior & Organization, 63(4)*, 624-647.

He, B. (2008). Status quo, factors and countermeasures of technology transfer center construction in universities (高校技术转移中心建设的现状、制约因素与对策). *Research in Higher Education of Engineering, 3*, 55.

He, J.S., Si, Y.B. (2010). Research on the approaches to promote the development of technology transfer intermediaries in China (促进我国技术转移中介机构发展的途径研究). *China science and technology forum, 1*, 158-161.

Howells, J. (2006). Intermediation and the role of intermediaries in innovation. *Research policy*, *35*(5), 715-728.

Huang, R.G. (2010). A brief introduction to the Japan's science and technology legal system (日本的科学技术法制体系简述). *Science & culture review, 3*, 46-63.

Jia, Y.W. (2002). Improve the service system to promote technology transfer from universities(完善服务体系促进高校科技成果转化). *Forum on science and technology in China, 4*, 72.

Jia, X.H., Pan, F. (2010). The enlightenment of Japan's TLO on the transfer of intellectual property rights (IPR) to China(日本技术转移机构(TLO)经验对我国重大专项知识产权（IPR）转移的启示). *Science and Technology Innovation Herald, 1*, 250-254.

Kneller, R. (1999). Intellectual property rights and university—industry technology transfer in Japan. *Science and Public Policy, 26(2)*, 113-124.

Kneller, R. (2003). University-industry cooperation and technology transfer in Japan compared with the United States: Another reason for Japan's economic malaise. *U. Pa. J. Int'l Econ. L., 24*, 329.

Landry, R., Amara, N., Rherrad, I. (2006). Why are some university researchers more likely to create spin-offs than others? Evidence from Canadian universities. *Research Policy, 35(10)*, 1599-1615.

Li, F. (2008). Analysis on the development mechanism of science and technology intermediary service system (科技中介服务体系发展动力机制分析). *Scientific and technological progress and countermeasures*, *25(4)*, 101-103.

Li, J., Yu, H.P. (2008). The operation mode and development trend of science and technology intermediary institutions (科技中介机构运作模式及发展走向). *Science and Management, 28(2)*, 87-88.

Li, X.L. (2014). An analysis of the macro-driven mechanism of the operation of Technology Transfer Organization in Japanese universities(日本大学专利技术转移组织运行的宏观驱动机制探析). *Contemporary Economy of Japan, 4,* 55-63.

Li, Y.Z. (2012). Status quo and countermeasures of personnel composition in patent transfer institutions of universities in China(我国高校专利转化机构人员组成现状及对策), *Science & Technology and Economy ,146,* 8690.

Li, W.B. (2011). The gap between China's science and technology intermediary service system and developed countries and its countermeasures (我国科技中介服务体系与发达国家的差距及对策), *Forum on Science and Technology in China*, *7,* 153-160.

Miesing, P., Tang, M. (2018). Technology transfer institutions in China: A comparison of value chain and organizational structure perspectives. *The world scientific reference on innovation*, *1*, 43-60.

Michiharu, N.(2012). JST's activity: Promoting technology transfer and innovation transfer and innovation, Retrieved 4 June 2019 from https://www.britishcouncil.jp/sites/default/files/edu-michiharu-nakamura-keynote-en.pdf.

Ministry of Education, the People's Republic of China. (2016). Compilation of statistics on science and technology in colleges and universities in 2016 (2016 年高等学校科技统计资料汇编). Ministry of Education, Retrieved 5 June, 2019 from www.moe.gov.cn/s78/A16/A16_tjdc/201703/W020170303298684014598.pdf.

Ministry of Internal Affairs and Communications. (2016). Survey on promotion of innovation policy (イノベーション政策の推進に関する調). Retrieved 4 June, 2019 from http://www.soumu.go.jp/menu_news/s-news/107493.html.

Miyagawa, Y. (2005). JST Training Program for Specialists of Technology Transfer. *Journal of Information Processing and Management*, *48*, 32-39.

Motohashi, K. (2005). University–industry collaborations in Japan: The role of new technology-based firms in transforming the National Innovation System. *Research policy*, *34*(5), 583-594.

Mowery, D. C., Rosenberg, N. (1999). *Paths of innovation: Technological change in 20th-century America*. UK: Cambridge University Press.

National Institute of Science and Technology Policy (NISTEP). (2010). Survey on university start-ups in 2010, Retrieved on 8 July, 2019 from http://www.nistep.go.jp/archives/3186.

OECD. (1997). National innovation systems, Retrieved 5 June, 2019 from https://www.oecd.org/science/inno/2101733.pdf.

OECD. (2009). OECD reviews of innovation policy China, Retrieved 4 June, 2019 from https://www.oecd.org/sti/inno/oecdreviewsofinnovationpolicychina.htm.

Onishi, R. (2017). Industry-academia collaboration at Kansai TLO(関西 TLO の目指す産学連携). *Journal of industry-academia-government collaboration*, *13*(2), 2_43-2_46.

Peng, Y., Wang, L. A., Liu, W. H., Sha, S. (2008). Research on cooperative alliance of science and technology intermediaries(科技中介机构的合作联盟研究). *China Economist*, *6*, 24-25.

Pollard, D. (2015). Innovation and technology transfer intermediaries: A systemic international study. *Innovation through Collaboration*, 137-174.

Prónay, S., & Buzás, N. (2016). International investigation and analysis of Japan and Europe on the success of the university's technology transfer activities (大学における技術移転活動の成功要因に関する日本及び欧州の国際調査分析). *Partnership*, *4*, 6P.

Qing, J., Wang, Y. (2015). The position of science and technology intermediary organizations in the transformation of scientific and technological achievements (科技中介机构在科技成果转化中的定位). *Chinese University Science & Technology*, *6*, 129.

Ren, Y.Y., Zhao, Z.Y., Du, H.L. (2012). Overview of Japan's technology transfer system(日本技术转移制度体系概述). *Science technology and law*, *95 (1)*, 68-70.

Sakai, T. (2011). Management reform of Kanai TLO (関西 TLO の経営改革). *Journal of industry-academia-government collaboration*, 4-8.

Shen, Y.N., Zhang, C., Zhu, G.F., Sun, D.B. (2016). Problems existing in the transformation of scientific and technological achievements in universities and its causes and solution (高校科技成果转化存在的问题, 成因及解决办法). *Chinese University Technology Transfer*, *3*, 8-11.

Smedlund, A. (2006). The roles of intermediaries in a regional knowledge system. *Journal of Intellectual Capital*, *7*(2), 204-220.

Takenaka, T (2005). Technology licensing and university research in Japan. *International Journal of Intellectual Property-Law, Economy and Management*, *1*(1), 27-36.

Takenaka, T. (2009). Success or Failure-Japan's National Strategy on Intellectual Property and Evaluation of Its Impact from the Comparative Law Perspective. *Wash. U. Global Stud. L. Rev.*, *8*, 379.

Takafumi, Y. (2013). University-industry collaborations in Japan, Retrieved 4 June, 2019 from http://www.innovationbycollaboration.se/wp-content/uploads/2015/09/Takafumi-Yamamoto.pdf.

Thursby, J. G., Jensen, R., Thursby, M. C. (2001). Objectives, characteristics and outcomes of university licensing: A survey of major US universities. *The journal of Technology transfer*, *26(1-2)*, 59-72.

WIPO. (2006). Technology transfer and development, Retrieved from 5 June, 2019 from https://www.wipo.int/wipo_magazine/en/2006/05/article_0005.html.

Wu, H.C. (2008). Factors restricting the construction of China's science and technology intermediary service system, *Technology and innovation management*, *29 (5)*,

438-440.
Wu, B.K. (1998). Power and knowledge: the history of British and American technology policy(权力与知识:英美科技政策史). China: *Fujian people's publishing house*, 105.
Wu, Y.R., Qiao, J. (2016). Research on the status quo of national technology transfer centers in China (我国国家技术转移示范中心现状调研). *Tianjin science and technology*, *4*, 15-17.
Xiong, X.Q. (2007). Constructing China's open science and technology intermediary information service system(构建我国开放式科技中介信息服务体系). *Future and Development*, *10*, 23-27.
Woolgar, L. (2007). New institutional policies for university–industry links in Japan. *Research Policy*, *36*(8), 1261-1274.
Xu, Y.S., Zhang, S.Y., Zhang, S.J. (2006). Analysis of technology intermediary organization from the perspective of knowledge activities(基于知识活动视角的技术中介组织分析). *Science & Technology Progress and Policy*, *7*, 168-170.
Yang, D.M. (2003). Experience of Japan's science and technology intermediary organization construction (赴日考察体会-对日本科技中介机构建设的感受). *Science and technology of Tianjing*, *10*, 26-29.
Yang, S., Jia, M.D. (2004). Innovation and development of China's science and technology intermediary service system (关于我国科技中介服务体系的创新与发展). *Journal of Xidian University*, *4*, 93—97.
Ye, G.L. (2004). Research on operation mode of university technology transfer center(大学技术转移中心运作模式研究). *Inquiry into economic issues*, *4*, 92-95.
Yin, X.L., Zhang, Z.J. (2006). The analysis of science and technology administration system reforming and its effects in Japan (日本科技行政管理体制改革与成效分析), *Science and Management of Science and Technology, 27(7)*, 15.
Zhang, G.A., Wu, K.S., Liu, G.Q. (2006). Enlightenment of science and technology intermediary service mode in western developed countries to China (西方发达国家科技中介服务模式对我国的启示). *Scientific and technological progress and countermeasures*, *12*, 24.
Zhang, H.J. (2009). The basic idea of establishing the growth mechanism of science and technology intermediaries (建立科技中介机构成长机制的基本思路). *Theoretical Exploration*, *1*, 91-94.
Zhang, R.K., Zhang, J.B., Yang, Y.W. (2007). Research on the status quo, problems and countermeasures of the construction of China's science and technology intermediary service system (我国科技中介服务体系建设的现状、问题与对策研究). *Science & Technology and Economy*, *20(1)*, 15-17.
Zhang, X.D. (2010). Technology transfer at Japanese universities and national research institutes(日本大学及国立研究机构的技术转), *China Invention& Patent*, *1*, 99.
Zhou, Y.M., Wang, X.L. (2009). Research on the role of science and technology intermediaries in the collaboration of industry, academia and research(科技中介机构在产学研结合中的作用研究). *Science and technology management research*, 8, 50-53.
Zhu, G.L., Peng, Y.F. (2003). Experience and enlightenment of building a technology

intermediary service system in developed countries (发达国家构建科技中介服务体系的经验及启示). *Science of Science and Management of S.&.T, 24(2)*, 77.