Review Paper

Technology Transfer for Commercialization in Japanese University: A Review of the Literature

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Abstract

The role of universities in knowledge-based economy has diversified and encompassed a 'third mission' of economic contribution beyond traditional instructional and research missions. Reforms in national research systems aiming to increase technology transfer and commercialization of university research have become a significant policy. Regarding the achievement of the United States (US) in the 1980s, the Organization for Economic Cooperation and Development (OECD) governments, including Japan, have considered and implemented various policies to revitalize the national innovation system toward a network-based approach. The purpose of this approach was to increase and encourage university technology transfer activities and support university commercialization.

This literature review of technology transfer and commercialization in Japanese universities is based on papers published between 1996 and 2013. The papers were obtained by querying *EconLit, Academic Search Complete,* and *Business Source Complete* using key-words: *university technology transfer, university industry collaboration,* and *university entrepreneurship.* This study analyzes Japanese university technology transfer from an aspect of external legal environments and then summarizes the impact on the University Industry Collaborations (UICs) following the enactment of UIC policies in the late 1990s. Major findings include that the policy initiatives had a positive impact on increasing Japanese university technology transfer. However, in terms of an external legal framework, the policy initiatives could not transform the exited system of technology transfer. To increase the efficiency of the collaboration, it is important to consider the type of university industry relationship as Japan has a strong informal system of collaboration between firms and university professors.

Keywords: technology transfer, university-industry collaboration, university entrepreneurship

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1. Introduction

In the knowledge-based economy, in novation and new techological development becomes increasingly important. Research universitie have adopted economic missions and become knowledge entrepreneurs (Fisher & Atkinson-Grosjean, 2002). The role of universities has diversified and encompassed a "third mission" of economic development beyond traditional instructional and research missions. Universities are increasingly viewed as proactive contributors to technological development and economic growth (Meyer, 2006). Many countries are undertaking university reforms to augment autonomy and increase the commercialization of the results of publicly funded research (Lehrer & Asakawa, 2004; Slaughter & Leslie, 1997; Zhao, 2004; Rasmussen, 2008).

Reforms in national research systems aiming to increase technology transfer and the commercialization of the university research have become a significant policy. The United States Bayh-Dole Act of 1980 is one of the most influential policy legislations to stimulate the commercialization of university research (Rasmussen, 2008). The policy changes and increased expectations that universities should contribute to the commercialization of research have led to several initiatives at the university level. The universities have also reconsidered their policies to create incentives for the researchers to contribute to the commercialization of their research results (Lockett, et al., 2003; Roberts & Malone, 1996; Rasmussen, 2008).

In the case of Japan, the additional role of universities in terms of economic contribution derives from the promotion of academia-industry cooperation. This collaboration began to attract attention during the Japanese economic recession in the 1990s (Fujisue, 1998). In order to solve economic problems, critically considering the establishment of solid economic foundations in the medium to long-term future is important. Japan needs to create new technology-based firms and ensure stable growth of essential industries (Fujisue, 1998). It is vital to effectively collaborate with universities and other institutions that have scientific knowledge in supporting these strategies (Motohashi, 2005).

An important motivation behind this collaborative policy is to make the Japanese National Innovation System (NIS) more dynamic and to shift the system from the dominant role of in-house R&D conducted at major firms toward one based on a network of active interactions among various innovators, including universities, industries, and government (Motohashi, 2005). In the light of the importance of this shift, the Japanese Government has administered various policies, including a Program of Economic Structural Reform and the Science and Technology Basic Plan, in which academia-industry collaboration is given priority to revitalize the NIS

(Fujisue, 1998). These strategies have been implemented with a network-based approach of University-Industry Collaboration (UIC) and the Japanese Science and Technology Basic plan has strongly advocated the promotion of active interactions among innovation leaders (Motohashi, 2005; Tantiyaswasdikul, 2012b).

This study addresses issues concerning policy initiative and the impact of policy implementation. The objective of this paper is to provide an overall background and a review of the literature associated with university industry-collaboration. This paper is organized as follows: I begin by describing the methodology and, in the next section, providing conceptual issues in technology transfer. Later, a review of the University-Industry Collaboration (UIC) Policy in Japan is presented. I then analyze and discuss the literature through the external legal framework and summarize the impact of UICs following the enactment of UIC policy in the late 1990s. The last section is the conclusion.

2. Methodology

A three-stage exploration process has been applied to develop a comprehensive overview and framework of the Japanese university technology transfer research. For initial access to the literature, I queried three subscription databases: *EconLit, Academic Search Complete,* and *Business Source Complete*, using the keywords *university technology transfer, university-industry collaboration, and university entrepreneurship.* The considered timeframe dated from 1996 to 2013.

Second, from the results of the topic, I drafted a list of peer-reviewed scientific journals where it was most likely I would find papers concerning this review: *Higher Education, Higher Education Research and Development, Industry & Higher Education, Journal of Evolutionary Economics, Journal of Innovation and Entrepreneurship, Journal of Technology Transfer, Management Science, Research Policy, Review of Economics & Statistics, Science and Public Policy, Small Business Economics, Social Studies of Science, Studies of Science, Technology in Society, Technovation, The American Economic Review,* and *The Journal of International Economic Law.*

Because of its relevance, a well-known working papers database of the Japanese Research Institute of Economy, Trade & Industry (REITI) is also included. I read the abstract of each paper on the previous list in order to find relevant articles. Third, I reviewed some interesting papers that were cited in the studies collected during the first two stages. Due to the impressive literature on the broad subject of university technology transfer, only papers explicitly focusing on Japanese university technology transfer and, university-industry collaboration has been included in this review.

3. Conceptual Issues in Technology Transfer

During the past three decades, the issue of technology transfer has received high attention from various academic researchers and policy-makers. The definitions of technology transfer are varied, according to the discipline and purpose of the research (Bozeman, 2000). However, works on technology transfer mainly focus on technology as an entity, and not on any particular applied science (Bozeman, 2000; Stock & Tatikonda, 2000). Technology transfer is the process by which technological research results are transferred into useful processes, products, or programs. Technology transfer is a movement of know-how, technical knowledge, or technology from one organizational boundary of the source to another (Stock & Tatikonda, 2000).

In the study of innovation and technical change, the term "technology transfer," refers to the process whereby an invention or an intellectual property from academic or public research is licensed through use rights to a for-profit entity and eventually commercialized (Freidman & Silberman, 2003). The transfer of technology is the diffusion of research knowledge through three major forms of mechanisms including conferences and scientific publications, the training of a skilled labor force, and the commercialization of knowledge (Landry, et al., 2006). Notable mechanisms of commercialization can be considered through consulting activities, research contracts with industry, patenting, and spin-off company formations (Landry, et al., 2006).

Before the 1980s, the majority of research focused on a cross-national technology transfer, especially the transfer of technology from industrialized nations to less developed countries. In the early 1980s, the research agenda shifted to domestic technology transfer, particularly in works by US scholars (Bozeman, 2000). The domestic technology transfer includes the transfer of technology among private sectors and between public to private sectors, the latter of which is becoming increasingly important. Expansion of federal laboratory roles and university roles in technology transfer and cooperative research, as well as other technology-based economic development programs in the cooperative technology model (Bozeman, 2000), has shifted the university's role to facilitating the third mission of economic contribution.

Transfer of technologies from universities to private sectors, and thus creating new businesses, is increasingly regarded as a significant role of universities (Harmon, et al., 1997). There are various models describing the process of technology transfer including a linear progression, networking arrangements, and long-term relationships between the two parties (Harmon, et al., 1997). In this study, I focus on the process of technology transfer from universities to industries as a model of linear progression, starting from idea generation and technology development at the

university, to patenting the technology, and finally the process of commercialization of the technology by licensing it to companies or by establishing university spin-offs.

4. University-Industry Collaboration (UIC) Policy in Japan

University-Industry Collaboration (UIC) has recently evolved in order to facilitate interaction between the two institutions (Takahashi & Carraz, 2009). However the relationship between universities and industry has a long history starting from the period of pre-war Japan (Motohashi & Muramatsu, 2011; Tantiyaswasdikul, 2012b, 2013). During that period, university professors played an active role in business startup, and technology transfers (Etzkowitz, et al., 2000; Motohashi & Muramatsu, 2011; Tantiyaswasdikul, 2012b, 2013). In 1886, the first Japanese Department of Engineering at the University of Tokyo was established with a long history of transferring knowledge and technology, as well as collaborating with industry (Takahashi & Carraz, 2009).

Between the 1920s and the 1930s, there were strong and effective linkages between large firms and universities in particular in Engineering, which took the role of pursuing industrially oriented research and development (Sakakibara, 2007). In the 1940s, during the Second World War, university and industrial research was geared to military purposes (Motohashi & Muramatsu, 2011; Tantiyaswasdikul, 2012b, 2013). The government took measures for the rapid expansion of scientific and technological departments at universities, and a variety of new research laboratories were set up to conduct war work (Sakakibara, 2007).

UIC activities declined in the post-war period because of the role played by the military, industry, academia, and government in Japan's militarization (Motohashi & Muramatsu, 2011; Tantiyaswasdikul, 2012b, 2013). In 1957, the Ministry of Education in Japan decided to promote scientific and technological education at the universities. Budgets for science and engineering departments were greatly increased to support material and institutional insufficiencies at universities. The Ministry also recognized the necessity of university industry-collaboration (Sakakibara, 2007).

In 1961, the Act on Research and Development Partnership that focuses on Mining and Manufacturing Technology was launched as the first pave-the-way policy for collaborative research among universities, industry, and the government (Motohashi & Muramatsu, 2011; Tantiyaswasdikul, 2012b, 2013). In 1967, the system began to accept engineers from industries as visitors in graduate programs and laboratories. Industrial leaders also acknowledged the urgent need to cooperate more closely with the universities not only in collaborating on industrial research, but also recruiting competent engineers (Sakakibara, 2007).

However, the shift toward closer ties between universities and industry was blocked by the student protests of the late 1960s (Sakakibara, 2007; Motohashi & Muramatsu, 2011; Tantiyaswasdikul, 2012b, 2013). When formal ties between academia and industry ended, university industry relations shifted to an informal mode (Etzkowitz, et al., 2000; Tantiyaswasdikul, 2012b, 2013). University industry relations were informal and active at the level of individual faculties such as scholarship funding and student employment sponsored by companies (Pechter & Kakinuma, 1999; Motohashi & Muramatsu, 2011; Tantiyaswasdikul, 2012b, 2013). The first major post World War II initiative to promote university industry interaction was promoted in 1983. This program was implemented to facilitate the joint research between universities and industries (Motohashi & Muramatsu, 2011; Tantiyaswasdikul, 2012b, 2013).

In this program, professors were the central entity, and companies provided these professors with researchers and funding to pursue specific research projects (Hane, 1999; Sakakibara, 2007). The system of joint research marked the starting point of official joint research activities and, until the beginning of the 1990s, Japan introduced a UIC system modeled on the basis of the United States' achievement in university industry technology transfer in driving economic growth (Motohashi & Muramatsu, 2011; Tantiyaswasdikul, 2012b, 2013). Due to its importance, the *Science and Technology Basic Law* was enacted in 1995 followed by many UIC policies in the first Science and Technology Basic plan (FY 1996-2000) that encourages the promotion of technology transfer from universities to industries, the Second Science and Technology Basic plan (FY 2001-2005) that reinforces university-industry collaboration and Intellectual Property (IP) management, and the Third Science and Technology Basic plan (FY 2006-2010) that reorganizes the major tool for innovation.

5. Japanese University Technology Transfer in External Legal Frame work

The focus on technology transfer to commercialization in particular in university research outcomes in patenting, emerged in the 1980s when there were major changes in federal law in the US including the passage of the Bayh-Dole Act of 1980 (Tantiyaswasdikul, 2012a). The Bayh-Dole Act or the Patent and Trademark Law Amendments act is the US legislation dealing with intellectual property (IP) management arising from federal government funded research. An assessment of the effects of this act shows that it made it significantly easier for American research universities to maintain the Intellectual Property Rights (IPRs) to inventions acquired from federally funded research (Henderson, et al., 1998; Tantiyaswasdikul, 2012a). The change appears to have had a powerful effect on the

way in which university research is transferred to the industrial sector and Technology Transfer Offices (TTOs), or Technology Licensing Offices (TLOs), have been established to support the many universities that are actively pursuing technology transfer activities (Henderson, et al., 1998; Tantiyaswasdikul, 2012a).

The TLO is one of the key mechanisms created by universities to facilitate the spillover of knowledge by commercializing research (Audretsch, 2013). Many universities, especially in the US, have established offices for patenting and licensing (Rasmussen, et al., 2006), and in most universities, IP management offices are also known as University-Industry Liaison Offices (UILOs) or Technology Licensing Offices (TLOs) (Robinson, 2006). Serving as an intermediary between universities and industries, these offices are "the university's broker in the knowledge market" (Fisher & Atkinson-Grosjean, 2002; Robinson, 2006).

The significant growth in patenting and licensing by US universities has been widely cited as an effect of the Bayh-Dole Act initiative. There are several arguments presenting that the increase of these activities enhanced the social returns to publicly funded academic research (Mowery & Sampat, 2005; Tantiyaswasdikul, 2012a). Although there is little empirical analysis that has been directed at assessing its impacts, these assessments and other factors have led governments in many OECD countries including Japan to consider policy initiatives that emulate the Bayh-Dole Act (Mowery & Sampat, 2005; Tantiyaswasdikul, 2012a). Japan adopted a similar policy to encourage university participation in technology transfer in the late 1990s. The following laws enacted between 1998 and 2004 have changed the Japanese legal technology transfer framework:

1. The 1998 Law to Promote the Transfer of University Technologies (TLO Law)

2. The 1999 Law of Special Measures to Revive Industry (The Japanese Bayh-Dole Law)

3. The 2000 Law to Strengthen Industrial Technology

4. The 2004 University Incorporation Law

Before the enactment of the University Incorporation Law, Japanese national universities were funded and controlled by the Ministry of Education, Science, Sports and Culture (MEXT) and had no independent legal status apart from MEXT. Formal technology transfer procedures for Japanese national universities were set out in several of official 'notifications' issued by MEXT, and internal rules that individual national universities enacted to implement the notifications (Kneller, 1999). The IPR of an invention made by a faculty member at a national university was, in principle, attributed to the inventor, and was to be granted to the university only on an

exceptional basis. Such exceptions were inventions achieved with application researches that utilized special government research funds, or particular large-scale government research facilities that were installed for special research purposes (Shimoda, 2005).

For appropriate invention management, each university stipulated invention rules and set up an invention committee. After the committee submitted their patent ownership assessments, the president of each national university made the final decisions. Once an invention was deemed to be state-related, the patent application, including all expenses, fell under the government's responsibility. Then the Japan Society for the Promotion of Science (JSPS), an affiliate of MEXT, handled most patent applications on behalf of national universities and the Japan Science and Technology Corporation (JST, an affiliate of the Science and Technology Agency, STA) licensed most national inventions (Kneller, 1999).

The study by Kneller (1999), based on the Japan Patent Office (JPO), showed that Japanese companies neither develop, nor license approximately two-thirds of the technologies for which they actually obtain patents, usually because the companies are not interested in the technologies and they want to block other companies from using them. Many university discoveries are informally transferred to the private sector and unaccounted for in any normal statistics (Kneller, 1999). Sometimes the transfer of IPRs occurs with a short document that serves as an assignment, rather than an official or contract agreement. These unofficial documents lead to the problem that some productive faculty members do not know how many of their discoveries have been patented by companies (Kneller, 1999).

Informal transfer of university technologies occurs in many ways: professors' consultancy for companies; corporate researchers, working in university laboratories, communicate research results back to their companies; or graduates find employment in industrial sectors (Kneller, 1999). These informal channels of technology transfer are rarely captured in official statistics. Based on the foregoing analysis, we may conclude that we cannot measure the vast majority of technologies that are transferred from university contribution.

To encourage the formal tie of UIC and technology transfer, the Japanese government has implemented the TLO Law to legitimate and facilitate transparent and contractual transfers of university discoveries to industry. Under the framework of this law, the following measures will apply to any universities whose technology transfer plans are approved by MEXT and the Ministry of Economy, Trade and Industry (METI). Technology transfer plans must include the establishment of TLOs, which will manage the patents of universities and promote licensing

to private sectors (Fujisue, 1998; Takahashi & Carraz, 2009).

The Japanese government has implemented many policies to support and encourage TLO activities; these include the subsidy and debt guarantee to TLOs, a subsidy of 50% and a full debt guarantee to the establishment cost of a TLO by universities and private companies through the "Industrial Infrastructure Fund"; exemption from fees for patent registration and maintenance; financing of the collaboration between universities and small-medium sized companies by the Small-Medium Sized Companies Supporting Corporation program (Fujisue, 1998).

TLOs were established outside the university framework as stock companies, except for private universities where they are placed within the university organization (Shimoda, 2005). IP management offices have always worked from within the university. There are three different types of TLO models.

The first one is the Internal model where IP management offices and TLOs are merged within the university. This structure is usually seen in private universities and in some national universities that have launched their TLOs in the previous years (Takahashi & Carraz, 2009). In this configuration, the two structures coexist within the university, but there is a division of labor. IP management offices take responsibility for the invention disclosure process, the management of IPRs resulting from contractual research, and the patent application process with the JPO. TLOs are in charge of the practical use of the IPRs, such as finding licensing partners and supporting the creation of university spin-offs (Takahashi & Carraz, 2009).

The second type is the *External & Exclusive* model, which occurs in most national universities. In this model, the TLOs are established outside the university structure and they have responsibility for the commercialization of their university inventions. The third type is the *External & non-Exclusive* model. In this case, one university has alliances or cooperation agreements with more than two TLOs, depending on its policy and characteristics. This type is concentrated in the Kansai region where many universities are grouped in a relative small territory; this model is rarely seen in the rest of Japan (Takahashi & Carraz, 2009). One of the most remarkable examples of the *External & non-Exclusive* type is the Kansai TLO, which has established formal partnerships with Kyoto University, Kyoto Prefectural University of Medical, Nara Medical University, Wakayama University, Kyushu University, and Okayama University (Kansai TLO, 2013).

Besides the TLO Law, the Japanese government also enacted the Law of Special Measures to Revive Industry, or the Japanese Bayh-Dole Law. The Japanese Bayh-Dole Law is similar to the US Bayh-Dole Act that allows universities to retain their rights

in any inventions deriving from public funded research. This policy has changed the IPR system of Japanese universities and shifted ownership from individual inventors to universities. To encourage UIC activities, the 2000 Law to Strengthen Industrial Technology has also been implemented to establish procedures through which university researchers can obtain permission to consult for, set up, and manage companies. It also accelerates the procedures of the industrial sponsored commissioned and joint research (Kneller, 2007b)

In April 2004, the Japanese government incorporated the national universities as *independent administrative entities.* This important change in Japan's research culture has allowed its universities to gain higher control in the legal system (Takahashi & Carraz, 2009). The roles of universities after incorporation have to be considered as conducting funded or cooperative researches, distributing research results to promote their utilization, and investing in organizations specializing in university technology transfer; however, the universities are autonomous and independent (Shimoda, 2005). They can more easily recruit academic and non-academic staff. Moreover, they can maintain the ownership of their invention, which was seldom the case before the Incorporation (Takahashi & Carraz, 2009).

6. The Impact to UICs Following the Enactment of UIC Policy

Regarding the recent development of UICs, under the Science and Technology Basic Plan, MEXT has promoted and encouraged financial support for the establishment of TLOs and IP management centers. Accord ing to MEXT (2009), by 2008, 58% of all universities and 92% of national universities had drawn up the IP policy (Okamuro & Nishimura, 2013). The number of joint R&D projects between national universities and private firms has risen remarkably from 56 in 1983, to 2,568 in 1998, and 14,303 in 2008 (MEXT, 2009). Together with private and public universities, the number of joint R&D projects in total reached 17,638 in 2008 (Okamuro & Nishimura, 2013).

Japanese universities have expanded their academic inventions as a result of the continuously increase in the number of patent grants since 1998 (Tantiyaswasdikul, 2012a). Based on data from the United State Patent and Trademark Office (USPTO), the continuous growth in the number of patents granted for Japanese national universities sharply increase during the period after the university incorporation law in 2004; the number of patents grew from 56 in 2000, to 246 in 2005, and 397 in 2006 (Tantiyaswasdikul, 2012a).

The achievement of UIC policies implementation in Japan has been proven and UIC activities have increased rapidly since the late 1990s. However, in terms of management, the Japanese government does not consider the result to be sufficient (Takenaka, 2005). Based on the investigation of the current system of IP ownership management in university inventions and the technology transfer organizations, with the encouragement and support from the Japanese government and JPO, none of the Japanese universities' TLOs are self-sustaining because the costs for filing and executing patent applications are much more expensive than revenues earned by licensing their technology (Takenaka, 2005).

Japanese UIC policies in the late 1990's provide favorable results in general; however, strong IP policies pursued by universities may reduce the incentive for firms to commercialize inventions resulting from UIC collaborations (Motohashi & Muramatsu, 2011). This conclusion corresponds to the analysis of Okamura and Nishimura (2013) in terms of the incentive of firms to participate. The IP policies of partner universities regarding equitability and flexibility influence the decision making to involve industrial sectors. However, their impact on UIC performance is only partially mediated by the level of the firm's commitment to the project (Okamura & Nishimura, 2013).

Small firms can achieve higher productivity through UICs compared to large firms (Motohashi, 2005). This has been proven by the role of new technology-based firms participating in UIC activities in Japan; UICs are gaining momentum and are likely to play a strong role in replacing the existing Japanese system of innovation that relies mostly on in-house R&D conducted within large corporations (Motohashi, 2005). On the other hand, Walsh et al. (2008) examine the relationship between universities and corporations, and how the relationship has changed over time, in particular in both informal and formal linkages between professors and firms. The study reveals that there is an increase in commercial activity, especially in engineering and the biomedical area, during this era of reform. Above all, there has been a particularly large increase in the link between universities and Small and Medium Enterprises (SMEs), which may have been disadvantaged in the old system of gift-exchanges between large firms and professors.

However, in the preemption of university discoveries under joint research agreements, apparently the informal ties between professors and firms remain strong, where corporate donations also enable the preemption of discoveries (Kneller, 2007b). Considering collaboration in terms of joint researches, Kneller (2007b) suggests that these new activities supplement rather than replace the old gift-exchange system. The substantial Japanese university technology transfer system is a continuation of the system that existed

before the reforms (Kneller, 2007a) since most joint research inventions are jointly owned, giving the corporations automatic and royalty-free rights (Kneller, 2007b). Consequently, although there has been a significant increase in university commercial activity during this period, in particular links to SMEs, university industry linkages continue to be dominated by informal ties and gift-exchange (Walsh, et al., 2008).

7. Conclusion

Recently, systemic reforms to strengthen the collaboration of universities and public research institutions with businesses have advanced substantially. The policy initiative aiming to encourage university technology transfer to make contributions to the Japanese economy and society has a positive impact on the increasing number of joint R&D projects and university patents. However, the expectation that the policy can support the creation of new businesses or new technology based firms cannot be successfully accomplished since the legal framework is not the only factor influencing how the system function. Considering the appropriate type of collaboration for each industry is critical to support the long-term profit of existing firms and to encourage new spin-off formations.

Since 1998, important reforms have been made to the Japanese system of technology transfer, and national universities have become administratively autonomous corporations. The universities are able to assert ownership over their inventions. However, cooperation between TLOs and universities still needs to be encouraged and the challenge is how to make an effective UIC. Based on the foregoing analysis, we may argue that the Japanese Bayh-Dole Law introduced in the late 1990s has assisted research results at Japanese national universities to be transferred and commercialized.

Technology transfer and commercialization in Japanese university has grown continuously since the Japanese government made an effort to encourage university technology transfer activities through several policies. However, the legislation encouraging technology transfer is only a prerequisite of its development. Government support plays a significant role in promoting university technology transfer. However, the performance of university TLOs in terms of management is important since TLOs become a key element for the success of technology transfer.

Another aspect to consider is the relationship between universities and corporations. In the case of Japan, we have to take into account its long history of university industry-relationships that have created the informal tie of this collaboration since many studies reveal that this informal system of technology transfer has continuously existed for a long time. The encouragement of UIC policies by the Japanese government cannot transform the technology transfer system

entirety; however, this contribution can supplement the existing gift-exchange system.

The economic importance coupled with the complex nature of the university technology transfer combines to offer a wide range of interesting questions and demands a multiplicity of research methodologies. Many researchers consider university incentive policies as an important part of university technology transfer. Major findings conclude that there is a positive impact on the policy initiatives to increase Japanese university technology transfer. However, in terms of external legal framework, the policy initiatives cannot transform the exiting system of technology transfer. To increase the efficiency of the collaboration, considering the type of university industry relationship is important since Japan has a strong informal system of collaboration between firms and professors.

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