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The beginning of university entrepreneurship in Japan: TLOs and bioventures lead the way

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Abstract Following reforms between 1998 and 2004, Japan's technology transfer system closely resembles the U.S. Bayh-Dole system. Numbers of TLO patents and licenses and numbers of startups are respectable compared to U.S. numbers shortly after enactment of Bayh-Dole. However, capabilities of TLOs vary, average royalties are low, and business prospects for most startups seem limited. In contrast, joint research with companies is increasing rapidly. Most joint research inventions are jointly owned giving the companies an automatic de facto, non-transferable, royalty-free and license. Data from one university show a large proportion of engineering and materials/chemistry inventions are attributed to joint research with large companies, thus limiting opportunities for startup formation and licensing to other small companies. (In biomedicine, pre-emption of discoveries by joint research is less.) Pre-emption of university discoveries (often publicly funded) under joint research agreements recreates the pre-reform system, where corporate donations also enabled pre-emption of discoveries. Like the old system, the new system is advantageous to established companies. Strengthening the formal system (including programs to assist startups) may redress this balance and give Japan the benefits of both types of technology transfer systems.

Keywords Joint/sponsored research · Startups · TLOs · IP ownership · Large vs. small company collaborations · Biomedical vs. engineering inventions · International comparisons

JEL Classifications D23 · D73 · O32 · O34 · O38 · O57

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1 Introduction and summary

The objective of this paper is to describe the institutional transformation of Japan's system of technology transfer, in particular the impact on startups. On the surface, these changes have been far reaching. Between 1998 and 2004, Japan moved from a mixed system of either government or individual inventor ownership to a system very similar to that in the U.S., where universities can claim ownership of all inventions by their employees as a result of the 1980 Bayh-Dole amendments to U.S. Patent Law.[1]

The Japanese changes were motivated largely by concern that the traditional system of technology transfer was resulting in many university inventions being undeveloped. Government advisory committees concluded this was because universities did not have incentives or the legal authority to manage their own inventions so as to maximize their commercial (and societal) value.[2]

However, if industry has failed to develop a sufficient number of university discoveries, it is not because of lack of ties between companies and university researchers. Such ties have been numerous. Prior to World War II, university professors consulted frequently for industry (Hashimoto, 1999; Odagiri, 1999). Between the end of the War and the year 2000, formal relationships were discouraged. However important informal consulting networks existed, as described below. Open publications of university research results have remained important for private sector innovation (Cohen, Goto, Nagata, Nelson, & Walsh, 2002), and rates of co-authorship of scientific articles involving industry and university researchers have been equivalent to those in the U.S. (Pechter, 2001).

The reforms were aimed largely at developing a formal technology transfer infrastructure centered on licensing of well defined intellectual property (IP) rights, and at creating an incentive system that would support this formal system. Some advocates of reform seemed to anticipate such incentives leading to an entrepreneurial academic culture where license revenues and the growth of startups would spur universities as institutions, as well as individual researchers, to promote the commercialization of university discoveries.[3] This paper will summarize:

- the pre-1998 system of technology transfer based upon direct, informal transfers from individual academic researchers to industry,
- the four laws that went into effect between 1998 and 2004 and, on the surface, transformed the old system into a U.S.-style system of university ownership of IP and transfer by formal licenses,

[1] Strictly speaking these amendments apply only to inventions arising from U.S. Government funding.

[2] Frequent reasons for companies not developing university inventions included perceptions that the market was too small, and intention to use the patents only as bargaining chips in case they were sued (or wanted access to another company's technology) or to prevent competitors from using the discoveries. Other reasons included inappropriate assessment by the university inventors of the companies' needs, and lack of incentives for the university researchers to keep working with the companies on the inventions (because the benefits they would receive in terms of royalties, etc. would be minimal, even if the invention became a commercial success) (Kneller, 2003b, Monbusho, 1998). See also footnote 16.

[3] Based upon conversations with officials in MITI and Monbusho in the late 1990s. Also U.S. universities such as Stanford, U California and MIT that have high license revenues and/or numbers of startups were often cited favorably in government documents such as Monbusho 1998).

- the advent of technology licensing offices (TLOs)[4] and their progress in patenting and licensing,
- the growth in startups,[5] and finally
- the increase in joint research projects and how this represents a continuation of the old system that allowed established companies to pre-empt many university discoveries.

In terms of standard technology transfer indices, the accomplishments of Japanese TLOs have been quite respectable compared to U.S. TLOs in the years following Bayh-Dole. On closer inspection, however, there are points of concern: unevenness in TLO capabilities, low average royalties, and startups that generally appear weak. It may be that these same deficiencies characterized technology transfer in the U.S. in the 1980s and early 1990s and would be expected in any new TLO-centered technology transfer system ‘‘just coming up the learning curve.’’ However, at the risk of being pre-maturely critical, aside from a few TLOs and perhaps 40 biomedical startups and a smaller number of software startups that appear to be on growth trajectories, the most remarkable aspect of the new system is the rapid continuous rise in the number of joint research agreements. As this paper argues, the growing prominence of joint research is not so much an achievement of the new system as the continuation of the old—a system that allows direct transfer of inventions from a professor's laboratory to collaborating companies, where the terms of transfer are worked out largely between the professor and the company, and where the company is under few obligations to develop the discoveries or to pay substantial royalties. Moreover, this reconstituted old system circumscribes the new system—limiting the inventions the TLOs can manage and limiting growth opportunities for startups.

This situation is not necessarily detrimental from the perspective of encouraging technology development and quality academic research. Japan's history of direct ties between academics and companies has parallels in the long history of U.S. academics consulting for industry (see Etzkowitz, 2002), ties that have clearly benefitted academic research and industry, at least in some fields.[6] Also, the worst defects of the previous system have been corrected. Startups can now obtain exclusive licenses where the chain of ownership is unambiguous. In addition, the likelihood that companies will simply ignore potential university IP rights is diminished. Even when inventions are attributed to joint research agreements, they are reviewed by the TLO which determines whether the company is interested in the invention.[7] Also, if companies sponsoring joint research want *exclusive* rights to joint research inventions, they usually (but not always) have to negotiate a license with the university.

However, in the absence of a strong formal technology transfer system (and probably also in the absence of real individual and institutional entrepreneurialism), startups are probably disadvantaged with respect to access to university discoveries.[8]

[4] This is the term commonly used in Japan to refer to organizations responsible for licensing technologies from Japanese universities and government research institutes.

[5] In this paper, I use the term *startup* to refer specifically to new (venture) companies whose core technologies are based upon university discoveries. *Spinoffs* refer to companies formed from existing companies. *Ventures* refers generically to new companies, whose financing is primarily equity based.

[6] For example, see Rosenberg (1998) with respect to chemicals.

[7] At least this is the practice of the TLO I am most familiar with.

[8] Using examples from Japan, the reasons are described in Kneller (2003b & forthcoming).

At least this is the case in Japan, because of the pervasive presence of established companies engaged in joint research. Thus, in order to preserve growth opportunities for high technology startups, Japan (and maybe other countries in a similar situation, such as Germany) should continue to strengthen their formal technology transfer systems. They should also try to ensure a level playing field for startups and established companies with respect to access to university discoveries.

2 Pre-1998: Control of inventions under the donation system[9]

Before the reforms, the *nation* was supposed to own inventions arising from funds for specific R&D projects,[10] while *inventors* could retain ownership of inventions arising under standard research allowances or from corporate *donations*. Both categories of funding were approximately equal, and in theory one would have expected about half of inventions to be classified as national inventions (Kneller, 2003b). However, national ownership entailed management of the patent applications by government bureaucracies and non-exclusive licensing, and thus companies and many faculty inventors considered this designation undesirable.[11] On the other hand, faculty found donations attractive because they were free of many of the restrictions attached to other forms of funding. It was standard practice for large companies to distribute large numbers of small donations to many university laboratories.[12] Even today, donations remain the main source of corporate support for university research (MEXT, 2005).

The quid pro quo for receiving donations was that professors would inform donors of their research progress (i.e., serve as de facto consultants) and let the donors file patent applications. Also, they would encourage capable students to consider the donors as places to work upon graduation. To keep their side of the bargain, faculty inventors also wanted to avoid the national invention classification. Attribution of invention funding was easily manipulated. Thus almost all commercially useful inventions were attributed to donations or (less frequently) to the standard research allowances—when in fact, many benefited from project-specific government funding.[13] Thus, donations and officially tolerated misattribution of funding sources

[9] Kneller (2003b) describes in depth the historical, institutional and legal circumstances summarized in this section.

[10] Project specific funding includes MEXT Grants-in-aid (the main source of competitive government support for academic R&D), and contractual sponsored research (i.e., Commissioned and Joint Research), regardless whether the sponsor is a private or government organization.

[11] However, in most cases a company sponsoring commissioned or joint research could negotiate either co-ownership with the government or a license. But in either case it could not transfer rights to the invention to a third party—a likely disadvantage to ventures but not large companies.

[12] Thirty-nine Japan Bioindustry Association respondents (almost all large or established companies) to a 1997 questionnaire, indicated that each had on average of 156 university relationships, the vast majority based upon donations to individual professors. The averageexpenditure per relationship was less than 10,000 USD (JBA, 1998).

[13] *Project-specific* government support for university R&D is approximately three times greater than total industry support for university R&D. This does not take into account non-project specific support, university salaries, infrastructure, etc. almost all of which are paid for by the government. See Kneller (2003b). In fact, official OECD statistics indicate that as a percentage of total university research support, industry accounts for only 2.5% in Japan compared with 6.8% in the U.S. (National Science Board, Science and Engineering Indicators, 2004)

enabled the donor companies to appropriate numerous publicly funded research discoveries.

This form of technology transfer was fast and low cost. Should an invention be commercialized, companies were expected to pay only token royalties to the inventor.[14] The system enabled large companies to keep abreast of research along wide fronts related to their interests. In the case of some breakthrough discoveries, such as titanium dioxide photocatalysts, it has resulted in a large number of companies developing a variety of products based upon related university discoveries (Baba, Yarime, Shichijo, & Nagahara, 2004).

But because companies received university discoveries essentially for free, incentives to develop them were low unless they were clearly outstanding or directly relevant to a company's core business. My research on the pipeline drugs of Japanese pharmaceutical companies indicates that their numerous collaborations with university researchers usually involved basic science issues or narrowly defined research tasks and rarely lead to the discovery of actual drugs or drug targets. Nevertheless, they probably involved the transfer to the pharmaceutical companies of rights to many academic discoveries.[15] "Sleeping university inventions" unused by companies was a great concern of the government agencies that promoted the 1998 TLO law and the subsequent reforms.[16]

Also the system was disadvantageous to small companies, especially startups. Small companies could not compete in terms of the numbers of laboratories they could support. Nor, at least in the best known universities, could they compete in terms of the attractiveness of the jobs they could offer the professors' students.[17] Startups were additionally handicapped because uncertainty over invention ownership often discouraged private investment (Kneller, 2003b).

Aside from the intellectual property (IP) management system, personnel regulations prohibited faculty from consulting openly for companies, much less assuming a management position in a company. I know of no examples of a national university professor founding a company until 2000. In addition, universities as institutions had little stake in the technology transfer process. They could not receive royalties or to hold equity in start-ups, and had only limited rights to overhead (indirect cost) payments on research grants and contracts (Kneller, 2003b). Their administrative staffs were bureaucrats in the Ministry of Education, Sports, Science and Culture

[14] According to conversations with various researchers.

[15] See following footnote, and case studies in Kneller (2003b), particularly that related to Anges MG.

[16] Monbusho (1998) and footnote 2. One of the best documented cases of undeveloped university discoveries patented by private companies concerns a sample of 252 genetic engineering patent applications, each of which had at least 1 university inventor. Only 16% had issued as patents, and in the case of 62% examination by the Japan Patent Office had not even been requested. In a separate study also by the Japan Bioindustry Association (JBA) 116 patent applications filed between 1992 and 1996 by 39 JBA member companies were identified as emerging from cooperation with universities. The companies felt that only 21% were for discoveries of practical use to the companies. JBA (1998) summarized in Kneller (1999).

[17] Nevertheless, there are cases of small companies benefiting greatly from consultations with professors in well-known universities (Kneller, 2003a, 2007).

(MEXT, formerly Monbusho) who changed jobs every 2 years, sometimes moving to another institution.

3 Summary of the laws underlying the new system

The following laws enacted between 1998 and 2004, changed the legal technology transfer framework:

- The 1998 *Law to Promote the Transfer of University Technologies*[18] (the *TLO Law*) legitimized and facilitated transparent, contractual transfers of university discoveries to industry.
- The 1999 *Law of Special Measures to Revive Industry*[19] (the *Japan Bayh-Dole Law*) has the same effect as U.S. Bayh-Dole Law, *except that it did not apply to national universities until they obtained legal status as semi-autonomous administrative entities in 2004.*[20]
- The 2000 *Law to Strengthen Industrial Technology*[21] established procedures under which university researchers can obtain permission to consult for, establish and even manage companies. It also streamlined the procedures for company sponsored commissioned and joint research.
- The *University Incorporation Law*[22] gave national universities independent legal status when it went into effect in April 2004. Previously they were merely branches of MEXT. But by gaining status as independent legal entities, article 35 of Japan's Patent Law, which enables employers to require assignment to them of employee inventions, became applicable as did the Japan Bayh-Dole Law. MEXT has urged the incorporated national universities to assert ownership over commercially valuable inventions (MEXT, 2002).

These laws will be discussed further in the following subsections.

4 The advent of TLOs and progress in patenting and licensing

The 1998 TLO Law established a process for METI and MEXT to approve TLOs. Approval meant eligibility to transfer royalty revenues back to the universities and to receive government subsidies of approximately 180,000 USD

[18] [Daigaku nado Gijutsu Iten Sokushin Hou] (Law No. 52 of 1998)

[19] [Sangyou Katsu-ryoku Saisei Toku-betsu Sochi Hou] (Law No. 31 of 1999)

[20] Also the Japanese law authorizes, *but does not require*, Japanese S&T funding ministries to let grantees and contractees claim IP rights to the inventions they made under government funding. However, in the case of university inventions, METI has encouraged all agencies to apply the law, and with a few exceptions, all have complied (Kneller, 2003b). The main exception is the ERATO Program administered by the Japan Science and Technology Corporation (JST), now part of MEXT. JST continued to retain ownership of ERATO inventions by university researchers following incorporation of national universities.

[21] [Sangyou gijutsu ryoko kyouka hou] (Law No. 44 or 2000).

[22] [Kokuritsu Daigaku Houjin Hou] (No. 112 of 2003).

annually for up to 5 years.[23] The law did not change ownership of university inventions, nor did it establish a system to verity inventors' assertions that their inventions were made with donations, as opposed to project-specific research funds. Until 2004, TLOs could only manage inventions that the inventors voluntarily assigned to them, and national inventions were out of bounds. Nevertheless, the law legitimized the negotiated transfer of IP rights to industry, even though some of the inventions the TLOs managed probably should have been classified as national inventions on the basis of a rigorous assessment of sources of research funding (Kneller, 2003b). This legitimation of the transfer of IP rights to industry (particularly exclusive rights) was especially valuable for university startups, as noted in the next subsection.

Most TLOs affiliated with national universities were established either as independent for-profit corporations or as independent foundations, in order to be able to receive royalty revenues, hold stock in startups, and hire staff from outside MEXT at competitive salaries. None of these activities would have been permitted if they were offices within their universities.[24]

Beginning with 5 in 1998, the number of approved TLOs had risen to 39 by March 2005. Performance has been uneven. Some have done remarkably well. However, discussions with TLOs in various universities indicate that most are short-staffed, and all except one are operating in deficit. A frequently heard comment is that most can manage patent applications, but many lack the experience and resources to market inventions.

In 2003, just before incorporation of the national universities, MEXT established and began to subsidize 34 IP Management Offices *within* universities in order to bolster the TLOs and to give universities in-house IP management expertise. Their responsibilities overlap those of the TLOs, and they have final authority over patenting and licensing decisions. In some universities relations between the IP Management Offices and TLOs have been managed smoothly but in others there has been friction.[25]

Figure 1 shows the trends in patent applications and royalty income for approved TLOs and Fig. 2 shows U.S. data for comparison.[26] In 2003, 5 years after enactment

[23] Kneller (2003b). However, these cannot be used to pay salaries of permanent TLO staff nor the fees of outside patent attorneys. Many U.S. TLOs rely on subsidies from their universities, yet over time more are becoming self-sufficient (based upon conversations with U.S. TLO officials). Also despite operating deficits, it seems that many U.S. universities have decided that the long-term benefits (technology development, new company and job creation, and increased industry sponsorship of research) outweigh the shortfall in license revenue. Whether the same reasons justify subsidies in the Japanese case remains to be seen. Another potential problem with respect to Japanese subsidies is that they are distributed as equal size block grants by the central government, whereas in the U.S., decisions are made by the university. Thus the U.S. system may facilitate better alignment of technology management with overall university goals, for example, with respect to the emphasis that should be placed on startup formation.

[24] Even today, receiving and selling equity in university ventures is problematic for national university corporations. Also only universities that have been authorized by MEXT to establish *IP management centers* can easily hire staff from outside the university-MEXT system (see below).

[25] See Kneller (2004). Written just before the incorporation of national universities, the warnings in this article about bureaucratic gridlock came to pass in the case of some, but not all, of the TLOS that had already shown strong technology management capabilities.

[26] Japanese data in this paragraph are from METI (2006b) and various unpublished METI summary data sheets. U.S. data are from the AUTM licensing surveys, primarily AUTM (2005).

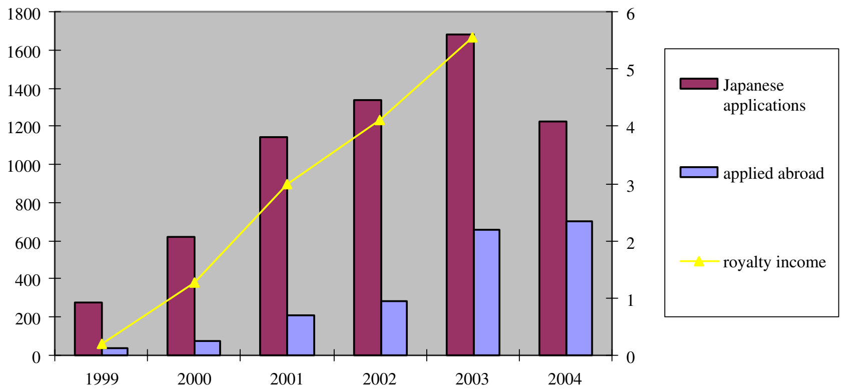

Fig. 1 Trends in TLO patent applications (left scale, #) and royalty income (right scale, 10^8 yen). *Source*: METI (various confirmed sources)

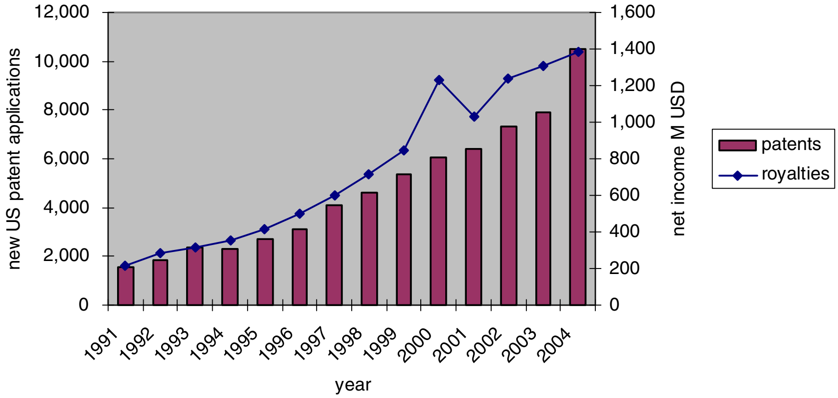

Fig. 2 Royalties and patent applications for U.S. TLOs. *Source*: AUTM (2005)

of the TLO Law, the 35 than-approved TLOs applied for 1679 Japanese patents, average 48 per TLO. In comparison, 109 U.S. TLOs applied for 1584 U.S. patents (average 15 per TLO) in 1991, 11 years after enactment of the Bayh-Dole amendments, and the earliest year for which U.S. data are available. Thus, the numbers of patent applications by Japanese TLOs are quite respectable compared to their U.S. counterparts.

However the 27 percent year on decline in Japanese applications in 2004 reflects the strains the system underwent during transition to a university ownership. Discussions with TLO officials suggest that this drop was due to confusion attendant the transition, the sudden increase in inventions reports overwhelming some TLOs, and friction between the IP Management Offices and TLOs in some universities. In other words, in some universities, a significant proportion of inventions that otherwise would have been managed by the TLOs were either managed by the new IP Management Offices or were left to the inventors. These same officials express optimism that universities are now coping better with the increased load of invention disclosures, cooperation is better, and the stronger TLOs are resuming lead responsibility for deciding which inventions to patent.

In 2004, Japanese TLOs issued 626 licenses, approximately 16 per TLO.[27] In 1991, 109 U.S. universities issued 1229 licenses (average, 11). Again, Japanese achievements are quite respectable compared to the most comparable U.S. data.

However, average Japanese royalties are probably considerably lower than in the U.S., even soon after enactment of Bayh-Dole. In 2003, Japanese TLOs received 5 million USD in royalty income. Average royalties per royalty-earning license was on the order of 17,000 USD, and this has probably not increased substantially.[28] In 2004, total license revenue shot up to 26 million USD. However, all but 3.7 million USD was earned by the University of Tokyo's TLO, mostly from sale of stock in OncoTherapy, Inc., a university bioventure that had a successful IPO in 2003. In comparison, in 1991 U.S. TLOs received 218.4 million USD in royalties on 2602 royalty earning licenses—about 84,000 USD per license. In 2004, this had increased to approximately 121,000 USD per license.[29] The fact that average royalties per license for U.S. universities have increased only moderately from 1991 to 2004 suggests that even in the early years following Bayh-Dole, U.S. universities were receiving larger royalties than did Japanese universities an equivalent number of years following enactment of the 1998 TLO law. The terms of licenses from Japanese universities of which I have knowledge also indicate that average royalties remain low and have not been increasing rapidly. Whether lower royalties reflect lower bargaining power (or willingness to bargain) on the part of Japanese TLOs or less valuable inventions is not clear. The more experienced TLOs do seek licensees abroad, so to some extent the royalties that Japanese companies are willing to pay should reflect international norms.

[27] Data from METI for the fiscal year ending 31 March 2005. During this fiscal year 38 TLOs formed before March 2005 issued licenses and I used this as my divisor.

[28] Year on year patenting and licensing data are not generally released by METI. The most recent year for which I have such data is 2002, when approved TLOs (28 as of the end of that year) earned 410.2 million yen in royalties on 216 royalty bearing licenses, for an average of 1.9 million yen (17,000 USD) per license. As of Sept. 2003, the 35 approved TLOs had *cumulative* royalty income of 107 million yen from 619 licenses that had *ever* earned royalties, for an average of 1.73 million yen (15,700 USD) *cumulative* per license. Although not equivalent to average annual income per royalty earning license, the fact that this average is lower than the 2002 average of 17,000 USD per license indicates that 2003 average annual royalties could not have increased substantially over the 2002 average. Neither, as the following text suggests, could they have increased substantially in 2004.

[29] AUTM (2005). Royalties vary according to whether licenses are exclusive or non-exclusive. Some inventions are licensed non-exclusively, others exclusively by field, some exclusively in their entirety, and some not at all. Thus data on average royalties per income earning license must be interpreted cautiously in both the Japanese and U.S. cases.

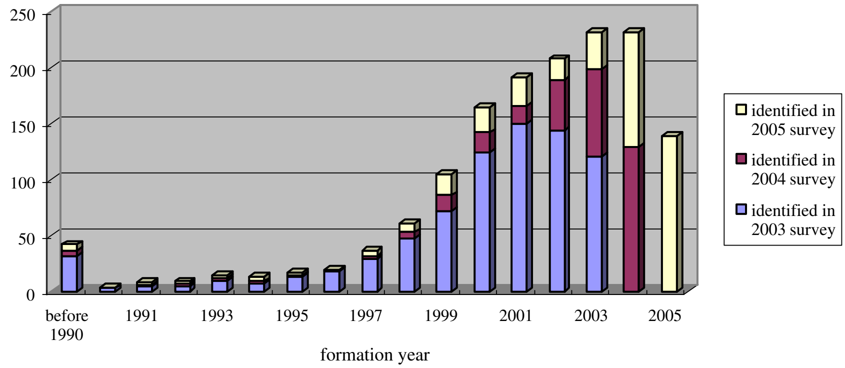

Fig. 3 No. Japanese startups formed per year. *Source*: METI (2005 and 2006)

5 The rise of university startups

The legitimation of negotiated transfers of exclusive IP rights to industry by the 1998 TLO was one factor facilitating the formation of university startups.[30] The 2000 Law to Strengthen Industrial Technology also facilitated startup formation by enabling university researchers to consult openly for companies and to manage startups.[31] Some of the most successful startups (particularly those of which have had IPOs, all of which are in biomedicine) owe their success largely to the laboratories from which they arose and to the faculty and graduate students in those laboratories. The general trend of startup formation shown in Fig. 3 suggests the influence of these two laws.

Figure 3 should be interpreted with caution, although the general pattern is probably accurate, including leveling off of the rate of formation. The bars include not only start-ups directly based upon university discoveries but also those with other ‘‘close’’ ties such as executives/founders who are recent graduates, and having recently engaged in joint research with a university. An analysis of the start-ups from the University of Tokyo, Keio University, and AIST indicates some of these ties are not close and that probably the most appropriate definition start-up is *a new company based directly upon one or more discoveries from the university*. Using this definition, the totals should be discounted by about 40%. Also about 10% of the listed startups are limited liability companies (LLCs) rather than joint stock companies.[32]

Even applying a 40–50% discount factor, however, the numbers of Japanese startups in the early years of the reforms seem quite respectable in comparison with

[30] As in the case of the U.S. (Shane, 2004; AUTM, 2005), most Japanese startups, even in non-life science fields, need exclusive licenses in order to be able to obtain venture capital financing. Kneller (2007) describes a case (that of the startup code named Big Crystal) in which a large company client insisted that it also receive a co-exclusive licenses to the same invention. This made obtaining of funding considerably harder for the startup, although it did eventually obtain funding.

[31] Prior to 2004, management positions had to be approved by the National Personnel Agency. Since then, all applications are approved at the university level. Applicants need to report the nature of the outside work, hours per week or month, and compensation. In the case of management positions, the goal must be to commercialize the researcher's university discoveries.

[32] Details of this analysis are in Kneller (2007).

startup formation in the U.S. Figure 4 suggests that in the early years following Bayh-Dole, rates of startup formation were probably well under 100 per year, and had only risen to around 200 per year close to 10 years after Bayh-Dole. Even discounting by 50%, Japanese startup rates were close to 100 per year 2 years after enactment of the 2000 Law to Strengthen Industrial Technology—again quite respectable in comparison with the most comparable U.S. data.

Other factors have also improved the environment for startups. Venture capital (VC) and public equity financing have matured. VC companies are now more likely than in the past to make equity as opposed to loan investments, to invest in newly formed companies and to invest in technology as opposed to service based startups. Special public equity markets have opened (equivalent to the Nasdaq in the U.S.) that have less stringent listing requirements and thus are more suited to the needs of startups and the needs of VC investors for an exit mechanism.[33] Several private VC companies focus on early stage investments in high technology ventures, mainly in the life sciences. Government institutions contribute approximately half of the investment capital of several of these VC companies. In addition, the government has its own VC organizations that often invest in technology startups. Several traditional VC companies have created special funds to invest in technology ventures, and some of these have negotiated agreements with individual universities under which they screen inventions for possible startup funding opportunities. Startups are also frequent recipients of government research contracts. These and other policies to support startups are described in Kneller (2007). All sources of financing considered, Japanese startups probably receive a larger proportion from public sources than do U.S. startups.[34]

About 38% of startups are biomedical-related, a share that continues to increase. Software is next (30%) followed by and machinery and devices (16%).[35] The

[33] The most important of these markets are Jasdaq (the over the counter market whose listing rules were relaxed in 1998), Mothers (a special section of the Tokyo Stock Exchange formed in 1999), and Hercules, the concessionary section of the Osaka Stock Exchange.

[34] Tsukuba (2005) reports survey responses from 269 startups related to source of initial stage financing. Overall about 60% came from the founder and friends and family, 28% from the *university* (probably mainly government sponsored research), 5% from venture capital and 7% from other sources. METI (2005) reports survey responses from 267 startups related to *post-founding but still early stage* financing. About 60% had received non-loan *government research subsidies or contracts* (0.9 M USD on average per recipient). About 41% received support from the founders (0.2 M USD on average). About 21% received support from relatives and friends of the founder (0.5 M USD on average). About 30% received VC funding (3.6 million USD on average). About 22% received equity investment from private companies (2.5 M USD on average). About 15% received angel investment (average 0.6 M USD). Roughly this suggests that about 20% of non-loan funding comes from research grants and contracts and an equal percentage from public VC—assuming that about half of VC invested in startups is from public sources (Kneller, 2007). AUTM (2005) indicates that external financing for newly formed U.S. startups comes from the following sources: family and friends 23%, venture capital 21%, angels 19%, state funding 9%, SBIR/STTR grants/contracts 8% and institutional funding 6.5%. Although these data are not directly comparable, they suggest public (including university) support accounts for around 23.5% of external financing for U.S. startups and around 30–40% for Japanese startups. Interviews with ventures summarized in Kneller (2007) also suggest that many high technology startups rely heavily on public funding.

[35] METI (2006). Some startups belong to more than one field, so percentages would sum to more than 100.

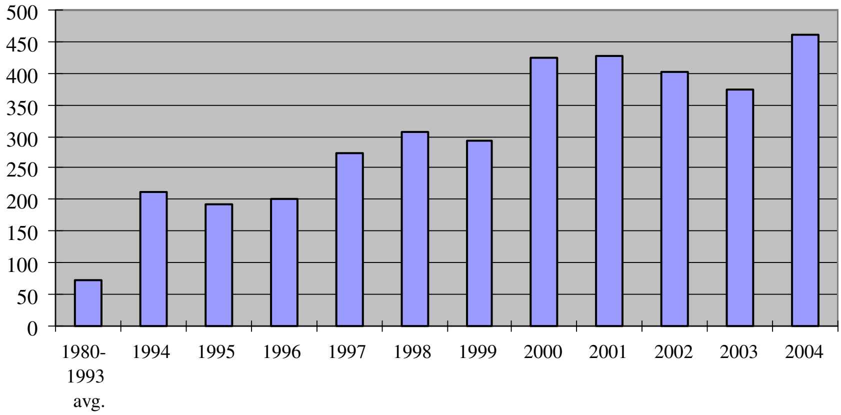

Fig. 4 No. U.S. startups formed each year. *Source*: AUTM (2005)

startups that have received the most investment, have the most employees and even the most sales, are in biomedicine.[36] Seven life science startups have had initial public offerings (IPOs) of their stock.[37] A few of the biomedical startups have drugs in clinical trials.[38] Yet the average size of even the life science startups is small.[39] In particular, their average number of employees is probably between one-ninth to one-half that of U.S. bioventures of equivalent median age. Also total sector employment appears to be just over one-third that of U.S. bioventures of equivalent median age. This is shown in the following table summarizing employment averages for therapeutic-focused Japanese bioventures existing in 2004 (which happened to have a median age of 4 years) and for U.S. companies of the same median age at two different points in time.

This suggests that Japanese companies are not growing as fast as their U.S. counterparts, and that total sector employment is considerably less than in the U.S. My interviews with over 30 Japanese bioventures also indicate that recruitment of

[36] Startups focused on drug discovery might not be expected to have significant sales. Yet Tsukuba (2005) and METI (2005) both show that on average life science startups have slightly higher sales than startups in IT or other fields.

[37] In 2002: Anges MG (Osaka U) and TransGenic (based in part on Kumamoto U discoveries). In 2003: MediNet (based in part on U Tokyo discoveries), OncoTherapy (U Tokyo) and Soiken (Osaka Foreign Language U & Osaka City U). In 2004: DNA Chip (Osaka U). In 2005: Effector Cell (U Tokyo).

[38] Probably on the order of 10.

[39] Median annual sales were probably below 0.5 M USD based upon Tsukuba (2005) which shows the median sales *among survey respondents that responded to the question on sales* was between 0.5 and 1.0 million USD. However only 26% of survey respondents responded to this question. My analysis of the business status of all startups from AIST, Keio, and U Tokyo in 2004 showed that 6 of 30 had annual revenue at least equal to 1 million USD and over half had negligible revenue. (Kneller, 2007)

Table 1 Employment in therapeutic focused Japanese bioventures in 2005 and U.S. therapeutic ventures of equivalent median age in 1987 and 1999

	All Japanese therapeutic ventures in 2004, employment assessed 2005	All U.S. therapeutic ventures formed 1981–1986, employment assessed 1987	All U.S. therapeutic ventures formed 1992/1994–1997/1998, employment assessed 1998/1999*
No cos.	113	33	98
Total employees	Slightly over 1463	3814	3900
Mean employees	Slightly over 13	116	40
Median employees	9.5	50	25

Sources and methods in footnote[40]

personnel and limited growth opportunities are major problems, even in companies with promising technologies and capable personnel.[41]

Other startups are, in general, even smaller.[42] Keio University and AIST have some software startups with annual sales over 1 M USD.[43] Outside of life science and software, the numbers of startups with substantial sales are small, and the number that appear to have unique core technologies is even smaller.[44]

Such assessments may be pre-mature. Also it is possible that one would find similar weaknesses in a comprehensive survey of startups in most regions in the U.S. Nevertheless, assuming that this weakness relative to U.S. startups in the 1980s is real, some of the factors alluded to above may partially explain it.

[40] JBA (2005) contains a list of all Japanese bioventures existing in 2004. I selected the 268 companies that had therapeutics listed as their first or second business focus and then randomly selected 30% of these to confirm the business focus and determine the number of employees using various public data sources. About 58% either did not have therapeutics as a significant business focus, were subsidiaries of larger companies, were LLCs, or were established earlier than 1975, and I excluded these from further analysis. Among the remainder, four was the median age since formation. About 70–80% were based upon university discoveries. (I could not find employment data on seven companies in my final sample. I assumed these companies each had fewer than 9.5 employees.) Dibner (1988 and 1999) contain lists of U.S. therapeutic bioventures, including numbers of employees, based upon surveys conducted in 1987 and 1998/1999, respectively. Selecting those companies established closest to Dibner's survey years, excluding LLCs and subsidiaries, and working backwards year by year until I had a set of companies that also had a median age of 4 years at time of survey gave me two sets of U.S. companies that I used as comparitors to the Japanese ventures. *It is not clear from Dibner (1999) whether employment was assessed in 1998 or 1999. Thus I calculated separate employment averages assuming employment was assessed in 1999 (for which I included companies formed 1994–1998 to obtain a median formation year of 1995) and in 1998 (for which I included companies formed 1992–1997 to obtain a median formation year of 1994). The figures in this column represent an average of these two sets of calculations.

[41] Kneller (2007), which also discusses reasons for lower employment in Japanese ventures.

[42] METI (2005), Tsukuba (2005) and note 39.

[43] In 2004, Keio had four, AIST had one. See analysis of AIST, Keio and U. Tokyo startups in Kneller (2007).

[44] Of 25 independent AIST, Kieo and U Tokyo startups not in software or life science, only 6 had annual revenues of at least 1 million USD in 2004, and over half had no publicly listed revenue data. See Kneller (2007) for case studies of some materials and engineering start-ups that appear to have unique technologies and capable researchers, as well as an overall analysis of the AIST, Keio and U Tokyo startups.

First, as a result of the 2000 Law to Strengthen Industrial Technology, it may be too easy for professors to form startups and remain as de facto directors.[45]

Second, Japan's corporate law permits companies to be incorporated with just one yen paid in capital. A large number of weak companies may be the natural result, but this may encourage entrepreneurship and increase the likelihood of some strong companies being created.

Third, government programs to aid ventures may be too generous. Some companies may become dependent on government contracts or capital, and some companies with little prospects for long term commercial viability remain in business.

Fourth, the continued immaturity of capital markets may deprive some promising ventures of financing. In particular, many VC companies and large institutional investors are often not able to assess the technologies and personnel of high technology startups (Kneller, 2007).

Other more complex reasons may include social attitudes, personnel practices in large companies, labor mobility, relations between large and small companies, and government policies with respect to R&D consortia (Kneller, 2007). But probably one additional important reason is that the increase in joint research projects is enabling established companies to pre-empt university discoveries.

6 Joint research and the pre-emption of university discoveries

Figure 5 shows that joint research has increased dramatically beginning around the start of the IP ownership reforms. By eliminating bureaucratic obstacles to multiple year contracts and the disbursement of funds, the 2000 Law to Strengthen Industrial Technology made joint and commissioned research more attractive mechanisms for companies to collaborate with universities (Kneller, 2003b). Projects with large companies account for 70% of all projects, a proportion that has been declining only gradually since the 1990s. The average amount of annual funding per joint research project in 2004 was around 20,000 USD, nearly identical to the average in 2000 (MEXT, 2005).

Incorporation of national universities in 2004 meant that they would own all inventions made subsequently by their employees under commissioned and joint research. Universities rarely assigned to industry partners the right to apply for patents on such inventions. Rather, like their U.S. counterparts, they offer the partner the right to negotiate an exclusive license to such inventions—or to the university's portion when there are university and industry co-inventors.

However, Japan's patent law favors the industry partners in a way U.S. patent law does not. Article 73 of the former requires the consent of all co-owners of an invention before it can be transferred to a third party, even by non-exclusive license. Thus, so long as the company is a co-owner by virtue of co-inventorship or the terms of the sponsored research contract, the company can block the transfer of the

[45] Shane (2004) and others have argued that startups that are run by professional managers tend to do better than those run by academic founders. This sentiment is now common in Japan and many academic founders have yielded formal management authority to non-academics. Nevertheless, it is still fairly common for the academic founders to retain de facto control, and to hear criticisms that companies are being directed more by academic curiosity than business goals.

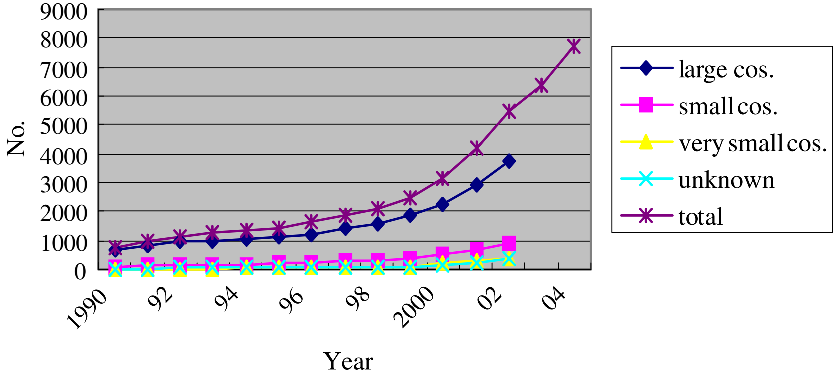

Fig. 5 New and on going joint research projects between private companies and national universities. Sources and definitions: see footnote[46]

university's rights to any other company. In other words, article 73 gives co-owners an automatic, de facto, non-transferable, royalty free exclusive license. (In contrast, a joint owner of a U.S. patent can transfer rights over the patented invention to a third party without the consent of the other joint owners.) In order to avoid this situation, joint research contracts now usually include a clause to bypass article 73. This allows the university to give a third party a non-exclusive license to its use rights, unless the co-owning company negotiates an exclusive license to the university's rights. However in practice, few third parties are interested in non-exclusive licenses if that would put them in potential competition with a large company.[47] In addition, large companies sometimes insist that the bypass clauses be stricken from joint research contracts. The universities, often at the urging of a professor who wants to keep good relations with the company, usually agree. In such cases, the joint research sponsor usually pays a majority of the patent application and maintenance costs, but has no obligation to develop the invention or to pay royalties unless it licenses the invention to a third party. Under such joint research agreements, control over inventions is just like it was under the donation system.[48]

My analysis of 143 inventions reported to the TLO of a major national university between February and July 2005, showed the following distribution of inventions by field: 46% engineering or IT hardware, 32% life science, 13% materials or chemistry, and 9% software.[49] About 31% of the inventions were attributed to joint research

[46] *Large* companies are defined as having over 300 employees, *small* as having 21–300, and *very small* as no more than 20 (except in the case of retail and service businesses where *very small* is defined as no more than 5 employees). Most startups would fall in the very small category in their first years of business. The 1990–2002 data are from Nakayama et al. (2005). The 2003–2004 data are from MEXT (2005) which does not give a breakdown by company size

[47] Based on conversations in Dec. 2004 with technology transfer officials at the National Institute of Advanced Science and Technology (AIST), one of Japan's major government research institutes, which, like most universities, also includes a clause to bypass article 73 in its standard joint research contracts.

[48] On a few occasions, companies that are co-inventors on inventions insist that no patent application be filed, essentially converting the invention into a trade secret.

[49] In cases of an invention that overlapped two of these categories, I assigned it 1/2 to each field. The full analysis and results are described in Kneller (2006).

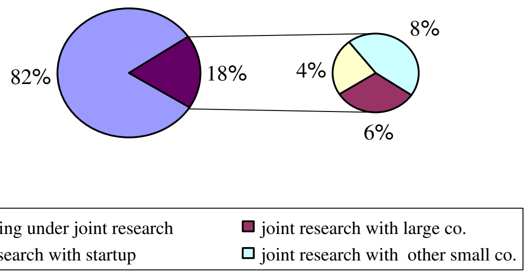

Fig. 6 Life science inventions

projects with private companies, *although such projects account for less than 6% of project-specific research funding in this university*.[50] The association between co-inventorship and inventions attributed to joint research is tight.[51] If companies expect interactions between researchers that might result in inventions, they usually conclude a joint research contract in advance. Similarly, companies seem to expect that if a joint research agreement is in effect and an invention arises, at least one of their researchers will be a co-inventor.

Only 18% of the life science inventions arose under joint research, and of these only one-third arose under joint research with large companies—the remainder arose under joint research with university startups or other small companies.[52] In other words, in life science fields, joint research accounts for only a small proportion of total inventive activity, and large companies are not using joint research as a means to appropriate a large proportion of university research results. The TLO is free to license most life science inventions to the companies it determines are most willing and able to develop them, including to new startups if the right combination of entrepreneurship, funding and market opportunities exists.

However, in the case of non-life science inventions, nearly 40% were joint inventions, and over 80% of these were with large companies. Thus, the TLO has management authority over a smaller proportion of these inventions. Figures 6 and 7 show this graphically: A small proportion of life science inventions are attributed to joint research and the joint research partner is often a small or new company. But joint research accounts for a much larger proportion of engineering, chemical and software inventions and the joint research partner is usually a large company.

I have continued to monitor invention reports and as of May 2006 have analyzed at least 150 additional invention reports. Although I have not tabulated these additional observations, their distribution seems similar to that described above.

This analysis deals with invention reports, not patent applications. This TLO files Japanese patent applications on roughly 30–40% of the reported inventions overall, but the application rate for joint inventions is 60–70%.[53] Thus, in terms of inventions

[50] Official university data book on file with author.

[51] In this sample only one of 45 joint research inventions did not have an industry co-inventor, and all inventions with industry co-inventors arose under joint research agreements.

[52] Unlike many U.S. universities, most Japanese universities permit joint and commissioned research between a startup and the founder's laboratory.

[53] In the latter case, the companies and universities usually file a joint patent application, and the companies usually pay a majority of the patent application and management costs. This is important for the majority of TLOs which face tight budget constraints.

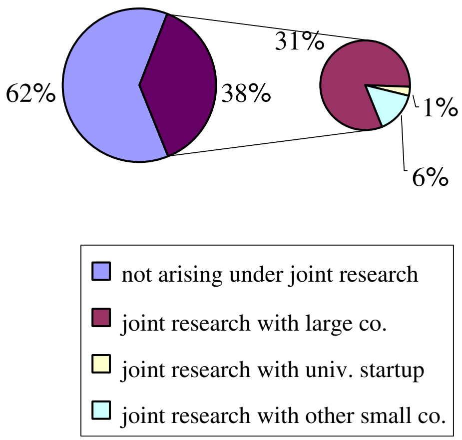

Fig. 7 Non-life science inventions

on which applications are filed, joint research inventions probably account for about half of the total, and a majority of non-life science inventions.

As for other universities, anecdotal reports from colleagues in some of the other TLOs indicate that rates of joint inventions are probably *higher* in most other major universities.

These findings are not necessarily negative. Economic pressures are forcing many large Japanese companies to rely more on collaborative research with universities than on basic research in their own laboratories.[54] From my vantage point in a major university, the numbers of industry researchers on campus is noticeably greater than 8 years ago, an impression supported by nationwide data.[55] Conversations with various university laboratories indicate that interaction between industry and academic researchers engaged in joint research usually is quite close. Also anecdotal assessments by industry executives suggest that industry is coming to regard joint research with universities as relevant to their business goals, i.e., more favorably than 5–10 years ago.[56]

Industry-sponsored inventions probably constitute less than 10% of the total among U.S. universities, and only a small fraction of these have industry co-inventors.[57] Thus, institutional barriers to cooperation between universities and established companies may higher in the U.S., and Japanese companies and professors may seek out collaborations with each other more readily than their U.S. counterparts.[58] It has been suggested that U.S. universities have focused too much on

[54] International Herald Tribune-Asahi Shinbun. 2004. Seeking profit, firms leave basic R&D to universities. 15 Jan. p. 21.

[55] Nationwide, the numbers of company researchers engaged in joint research in universities doubled from 1398 in 1992 to 2821 in 2002 (MEXT, 2003). The rise actually predates the IP ownership reforms. Even under the donation system, the only way corporate researchers could engage in research in universities was under joint research agreements or nearly equivalent *commissioned researcher agreements*.

[56] Discussions documented in Kneller (2007).

[57] Based upon a series of communications on this topic in 2004 and 2005 with an official in the technology transfer office of a major U.S. university who has been active in AUTM.

[58] However, any comparison along these lines ought also to take into account consulting and startup formation in the U.S.

ownership of inventions and license revenue, whereas they ought to place more emphasis on the support that industry can provide for ongoing research (Chabrow, 2005). Recent moves towards open collaborations in which companies support university research in return for any IP being freely available for academic and commercial use (at least with respect to open source software applications) reflect this perspective (IBM, 2006; Kauffman, 2005). However, such movements differ from the situation in Japan, where companies usually obtain exclusive IP rights under joint research agreements.

Many Japanese universities have good researchers but weak TLOs. In these universities, joint and commissioned research is the only effective mechanism of technology transfer, if startup formation is not feasible. Also, well known professors often engage in joint research with several companies, even from within the same industry.[59] So while pre-emption by established companies as a group may be of concern, pre-emption by individual companies probably is less so. Finally, in the case of the university whose inventions are analyzed above, the TLO is handling the overall technology transfer process quite well, consulting closely with inventors, making timely decisions whether to file patent applications, and in the case of non-joint research inventions, licensing to a wide range of large and small companies throughout Japan and overseas. Its licensees include one of the strongest groups of startups in the country. In other words, this university has shown that despite pre-emption by joint research of a large proportion of discoveries, promising opportunities for licensing and startup formation remain, although probably more so in biomedical than non-biomedical fields.[60]

On the other hand, having so many inventions flow automatically to companies takes entrepreneurial initiative away from TLOs and faculty members. There is little that TLOs or inventors need to do (or can do) to influence how these discoveries will be developed. Furthermore, the prevalence of joint research raises questions about a shift in focus from fundamental to applied research in universities. Are too many talented researchers settling too easily into a routine of doing applied research for industry while ignoring fundamental issues that hold the keys of the next generation of new product? (Or conversely, does close interaction with industry lead more quickly to deeper scientific understanding and breakthroughs?) Finally, the prevalence of joint research, while helping established companies to develop competence in new fields, has decreased the niches available for new companies to exploit, and is probably one of the reasons for the weakness of high technology ventures in Japan.[61]

Startups and other ventures also make use of the joint research system. However, because startups have already received key university IP through licenses, joint research does not offer them the same IP benefits in new fields of technology as it

[59] According to my observations, such professors will usually segment their research, collaborating with one company on a particular aspect and another company on another aspect.

[60] For reasons why pre-emption is less common in biomedicine, see Kneller (2007). It is possible that, even in engineering and materials science/chemistry, the most revolutionary inventions may be less likely to be pre-empted by joint research sponsors because they do not advance their immediate business objectives. However, Kneller (2007) discusses examples suggesting that, even without initial pre-emption, joint research may diminish opportunities for new companies to develop such pioneering discoveries.

[61] Kneller (2007). See also previous footnote.

offers established companies. In addition, startups sponsoring research in the founders' laboratories raise conflict of interest issues.

7 Conclusion

Two years after completing the transformation of the legal framework governing technology transfer, the system has gotten off to a credible start, with standard performance indices that are quite respectable in comparison with the U.S. system about a decade after enactment of the Bayh-Dole Law. The high points of the Japanese system include a few TLOs that have demonstrated good competence and somewhere on the order of 50 biomedical startups and a smaller number of software startups that are making significant progress. But the most remarkable aspect of the new system has been the growth in joint research agreements. This largely recreates the previous donation system, (without the threat of national ownership) and depends only tangentially on the changes related to the ownership and management of IP that are at the center of the reforms.

Other countries, notably Germany in 2002, have gone through similar transformations of their university IP ownership systems. It would be interesting to know whether the former system lives on through cooperative research as in Japan.

In any case, the larger question is whether the persistence of the old system and the limited success of the new formal technology transfer system strengthens or undermines the overall technology transfer effort. In Japan, the new dual system seems to be providing established companies with wide and rapid access to university technologies.[62] Preliminary survey data indicate Japanese engineering and biomedical faculty probably have more contact with industry (even small companies) than their U.S. counterparts and are more likely to see their research translated into commercial products or processes (Walsh, Yoshihito, Baba, Suzuki, & Goto, 2005). There are suggestions that research in Japanese universities is more attuned with the needs of industry (i.e., more applied) than in the U.S.[63] So aside from the last point (that perhaps applied research tends to be overemphasized relative to fundamental scientific inquiry), is there anything wrong with the Japanese system from the perspective of technology transfer? Perhaps it is superior to that in the U.S.

The problem with weak TLOs and weak institutional structures to promote startups is that such circumstances favor direct transfers by university inventors of their discoveries to the companies with which they are collaborating. This is probably particularly so in Japan where society-wide support systems for venture companies are still immature and where established companies have a large presence in

[62] See Fig. 5 and comments from industry officials summarized in Kneller (2007, chapter 7). My conversations with research managers and IP lawyers in large companies indicate they generally preferred the donation system, and often find TLOs and university IP Management Office personnel incompetent or bureaucratic. Nevertheless, since 2004, there has been a tendency to speak more favorably about the benefits of joint research with universities to their companies. Also when pressed as to whether they would prefer Japanese TLOs to behave as they do in the U.S., the almost universal response is that they prefer the more docile Japanese TLOs.

[63] See the analysis of sources of university funding in Kneller (2007, chapters 3 & 7). Also see the previous point, that Japanese biomedical scientists are more likely than their U.S. counterparts respond that a product or process to which they contributed is on the market (22 vs. 13% ''yes'' response) (Walsh et al., 2005).

university laboratories by virtue of joint research. Strong TLOs linked to incubators, university offices that can provide advice on starting a company, etc. provide an alternative to simply passing discoveries to collaborating companies. Without such components of a formal technology transfer system, active joint research with established companies circumscribes or eliminates new technology niches into which new entrepreneurial companies can grow (Kneller, 2007 last chapter).

Again this is not necessarily a negative situation, provided established companies collaborating with universities can be as innovative as new companies in terms of discovery and early stage development of new technologies. But the Japanese technology transfer situation does bring this question squarely to the fore, “Other factors being equal, do new companies have an early stage innovation advantage compared to established companies in various technical fields?” Of course it might be argued that even if the answer is affirmative, new Japanese high technology companies face so many other social and business obstacles that it does not make sense for universities to promote their growth, especially if that might conflict with the interests of established companies engaged in joint research. However, in view of the important role new high technology companies play in U.S. innovation, this seems to be a risky strategy.

In order simply to level the playing field between established companies and startups with respect to access to university discoveries, the following measures might be considered:

- Make identification of technologies appropriate for startups and liaison with outside venture capital and other startup support services a priority mission of TLOs.
- Ensure close coordination between the TLOs and the university offices managing joint research contracts.
- Ensure that the scope of joint research protocols is clearly defined and commensurate with the sponsoring companies research support.
- Claims of co-inventorship and attributions of inventions to joint research projects should be verified, or the basis for such claims should be clearly documented.
- Eliminate the remaining barriers to national universities taking equity from startups in lieu of cash royalties for licenses.[64]
- Either eliminate the provision in article 35 of Japan’s patent law that requires agreement of all patent co-owners to any license, or require a non-overrideable bypass of that provision in all university joint research contracts. In other words, in the case of jointly owned company–university inventions, if the company wants exclusive rights, it must negotiate for exclusivity invention by invention.
- Currently, uncertainty over conflict of interest issues is a serious barrier to productive relations between universities and startups. In order to provide clarity and flexibility, leading universities and government laboratories should employ on a long term basis at least one or two persons with interdisciplinary expertise to

[64] Despite moves by MEXT to allow national universities themselves to hold equity in startups, issues related to how much equity universities should receive in lieu of cash royalties for licenses and their access to the proceeds from the sale of equity still have not been resolved with the Ministry of Finance. However, for profit TLOs can receive and sell startup equity and channel proceeds back to their universities, alleviating this problem for universities with such TLOs.

be responsible for managing conflicts of interest and research-subject-protection issues.[65] They should have authority to make decisions on a case by case basis and (in consultation with government ministries) to evolve procedures that help ensure the safety or research subjects (particularly in clinical trials), scientific integrity, and the paramouncy of academic goals, while at the same time promoting the commercialization of university discoveries and maintaining a supportive environment for startups.

Even these narrowly focused measures will require concerted involvement of universities, their faculties and their TLOs, and consultation with government agencies and the business community. The history of the Japanese and U.S. technology transfer systems shows that the legal framework is but one factor influencing how the system functions. Real change requires much more effort than just changing the laws.

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