Japan's new technology transfer system and the pre-emption of university discoveries by sponsored research and co-inventorship

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Abstract: *Following the incorporation of Japanese national universities in April 2004, the ownership of university inventions is now similar to that in the USA. However, in contrast to the USA, joint research projects involving close collaboration with company researchers who are frequently named as co-inventors are common. A large proportion of university discoveries are passed directly to established companies under joint research agreements. This perpetuates the pre-2004 situation. It also raises concerns that large companies are pre-empting publicly funded discoveries and decreasing opportunities for new company formation. An analysis of inventions reported to a major national university indicates that one-third are attributed to joint research, and, among those inventions for which patent applications are filed, the proportion is still higher. The corresponding proportions at most other major universities are probably even higher than at this university. Pre-emption by large companies is more common in engineering and materials/chemistry than in the life sciences. Further cross-national comparisons are needed to assess the impact on innovation and basic research of the Japanese and US models of university–industry cooperation, and to guide policy.*

Keywords: *collaborative research; start-ups; technology transfer; IP management; innovation systems; Japan*

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This article describes the substantial transformation of Japan's university–industry technology transfer system since 1998.[1] Now universities have the right to assert ownership over all inventions made by their academics and other employees, just as US universities have had since the Bayh–Dole amendments to US patent law in 1980. Nevertheless, to a much greater extent than in the USA, established companies are using joint research

with university laboratories to pre-empt a large proportion of university discoveries. Because joint research projects in Japan often do involve close cooperation between company and university researchers, this may represent an effective form of university–industry cooperation and technology transfer.

However, it limits royalty revenue for universities and reduces their opportunities to manage proactively and champion their technologies. It also forecloses new technology niches to start-ups, except in the life sciences. In these respects Japan's new technology transfer system is a continuation of the system that existed before the reforms. Japan's experience shows that merely changing the legal framework of technology transfer will not necessarily change the system itself. Moreover, Japan's experience with reforms may reflect that of a number of other Asian and European countries. The remainder of this paper:

- summarizes the 1998–2004 reforms, emphasizing the similarity between the post-2004 system and the US Bayh–Dole system;
- reviews the modest progress to date of technology licensing offices (TLOs) in patenting and licensing;
- summarizes how the pre-reform system was inimical to start-ups, notes the respectable rise in the number of start-ups coinciding with the reforms, but also notes that the start-up boom probably has levelled off and that growth prospects for most start-ups are minimal except in the life sciences;
- discusses the dramatic rise in joint research projects and presents data from one university showing the extent of pre-emption enabled by such projects and how pre-emption differs by technology field; and
- summarizes the strengths and shortcomings of the US and Japanese systems and offers suggestions regarding policies and additional studies.

1998–2004 reforms: surface convergence with the US system

Since April 2004 Japanese national universities, which conduct most university research in Japan, have had the mandate to own and manage all the inventions of their employees. At that time they were incorporated as national university corporations, although they remain under the purview of the Japanese Ministry of Education, Culture, Sports, Science, and Technology (MEXT).[2] No longer simply branches of MEXT, they have the right under Japanese patent law to own inventions by their employees,[3] and MEXT has urged them to assert such ownership (MEXT, 2002). The National University Corporation Law was the fourth in a series of legal reforms that began in 1998 with the passage of a law promoting the establishment of technology licensing/transfer organizations (TLOs) with authority to license some university inventions and to channel royalties back to the inventors, their laboratories and their universities.[4] Prior to the National University Corporation Law, faculty inventors usually retained ownership of their inventions. However, in theory the government could have asserted ownership over about half of all inventions, and the resulting uncertainty over ownership was an additional barrier to start-ups.[5]

Most of the major Japanese universities have TLOs that have been approved and subsidized by the government in accordance with the TLO law. To be free of MEXT personnel policies and manage royalties more efficiently, most of the national university TLOs were formed as for-profit corporations or semi-independent foundations. However, many of them lack qualified staff and funds for patent prosecution. To bolster these TLOs and give universities in-house intellectual property (IP) management expertise, MEXT has also established more than thirty IP management offices inside universities. Their responsibilities overlap those of the TLOs and, at least in theory, 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.[6]

As a safety valve to ensure that invention management is not delayed, many universities have internal guidelines requiring them to decide within a limited time (usually about a month) whether they intend to apply for patents – otherwise rights to the inventions remain with the inventors. In another departure from standard US practice, students usually retain ownership over their inventions. Also, universities generally do not require corporate researchers engaged in collaborative research to transfer their rights as inventors or co-inventors to the university, even though the inventions may have arisen in university laboratories.[7]

As in the USA, universities rarely assign the right to apply for patents on inventions arising under sponsored (commissioned or joint/collaborative) research agreements to industry partners. Rather, the universities offer the partners the right to negotiate an exclusive licence to such inventions – to the university's portion when there are university and industry co-inventors.

However, Japan's patent law favours the industry partners in a way US 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 licence. 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 university's rights to any other company. In other words, article 73 gives co-owners an automatic, *de facto*, non-transferable, royalty-free exclusive licence. (In contrast, a joint owner of a US patent can transfer rights over the patented invention to a third party without the consent of the other joint owners.) 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 licence to its use rights, unless the co-owning company negotiates an exclusive licence to the university's rights. However, in practice few third parties are interested in a non-exclusive licence if it would put them in potential competition with a large company.[8] In addition, large companies sometimes insist that the bypass clauses are stricken from joint research contracts. The universities, often at the urging of the professor who wants to keep good relations with the company, usually agree. In such cases, the joint research sponsor typically pays a majority of the patent application and maintenance costs, but has no obligation to develop the invention or to pay royalties to the university unless it licenses the invention to a third party.

Patenting and licensing

The 1998–2004 reforms were intended to mobilize university research and development (R&D) more effectively for the benefit of Japanese industry and society. As in the case of the Bayh–Dole amendments to US patent law, it was hoped that universities would manage their discoveries better if they were given the control over royalties that comes with ownership.

Figure 1 shows the trends in patent applications and royalty income for approved TLOs. In 2003 the 35 approved TLOs applied for 1,679 Japanese patents – on average, 48 per TLO.[9] This is quite respectable in comparison with the 1,584 US patent applications filed by US universities and academic medical centres in 1991, eleven years after enactment of Bayh–Dole[10] – especially considering that, in 2003, almost all the inventions managed by TLOs were transferred to them voluntarily by faculty inventors.

However, royalties present a different picture. In 2003, approved TLOs in Japan issued 531 licences, but many of these earned no royalties. Total royalty income for that year was $5 million, while average royalty income per royalty-earning licence was probably of the order of $17,000.[11] In 2004, approved TLOs issued 626 licences and royalty income shot up to $26 million. However, all but $3·7 million was earned by one TLO,[12] mostly from sale of stock in a university start-up

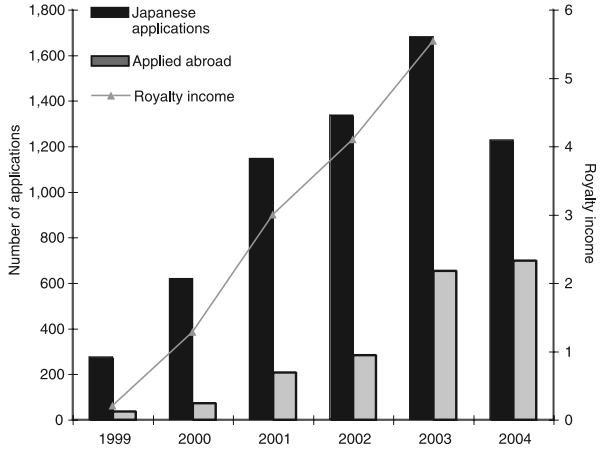

Figure 1. Trends in TLO patent applications and royalty income (unit=10^8 yen, roughly $1 million).

Source: Ministry of Economy, Trade and Industry (METI), various documents. Reproduced by permission.

that had a successful initial public offering (IPO) in 2003. In comparison, in 1991 US TLOs issued 1,229 licences and received $218·4 million in royalties on 2,602 royalty earning licences – about $84,000 per licence. In 2004 US university TLOs had $1.385 billion in net licence income from 11,414 royalty-earning licences – approximately $121,000 per licence.[13] US data earlier than 1991 are not available, so it is not possible to match Japanese licensing and royalties according to years following the 1998 TLO law with US licensing and royalties according to the same number of years following the 1980 Bayh–Dole law.

Nevertheless, the 1991 US data, coupled with the fact that average income from royalty-earning licences has been increasing only gradually, suggests that in the early years following Bayh–Dole US universities were receiving larger royalties than did Japanese universities an equivalent number of years following enactment of the 1998 TLO law. My observations in a major university also indicate that average royalties remain low and that they have not been increasing rapidly. Lower royalties in Japan are due in part to hesitancy on the part of universities to bargain with large companies for higher royalties and to pre-emption by large companies of many of the best inventions as a result of joint research agreements.

Also of interest is the 27% decline in TLO patent applications in fiscal year 2004. Discussions with TLO officials suggest that this was due to confusion resulting from the change in ownership systems, the sudden increase in invention reports overwhelming some TLOs and friction between the IP management offices and TLOs (in other words, 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, IP management offices and TLOs are cooperating better and the stronger TLOs are resuming lead responsibility for deciding which inventions to patent. Nevertheless, this sudden drop in patent applications attests to the strains the system has undergone and also the great variation in technology management capabilities among universities.[14]

Start-ups: detrimental effects of the old system

Promotion of university start-ups has been another major goal of the Japanese government. The pre-2004 IP ownership system was a major factor inhibiting entrepreneurship. Prior to 2004 the nation was supposed to own inventions arising under funding for project-specific R&D, while inventors could retain ownership of inventions arising under standard research allowances or from corporate donations, both these categories of funding being approximately equal (Kneller, 2003). Government ownership entailed management of the patent applications by government bureaucracies and non-exclusive licensing. Therefore, companies and many faculty inventors considered it undesirable. Attribution of invention funding was easily manipulated. 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.[15] In this way, donations enabled the donor companies to appropriate numerous publicly funded research discoveries.

Since most donations were small sums distributed by established companies among a large number of university researchers in expectation of receiving IP rights and capable graduates as new employees,[16] large established companies received IP rights to most commercially valuable university discoveries. Moreover, there was a cloud of uncertainty over the actual ownership of most inventions that the university inventors asserted to be theirs.[17] Usually this was not of concern to large companies, which were generally satisfied with the access the old system provided to university research. But so long as the threat of government ownership and its requirement for non-exclusive licensing existed, the old system was a bane for new companies – because they had to advertise their IP rights to receive funding, needed transferable IP rights and lacked large in-house research teams that could quickly make improvements on the professors' initial discoveries.

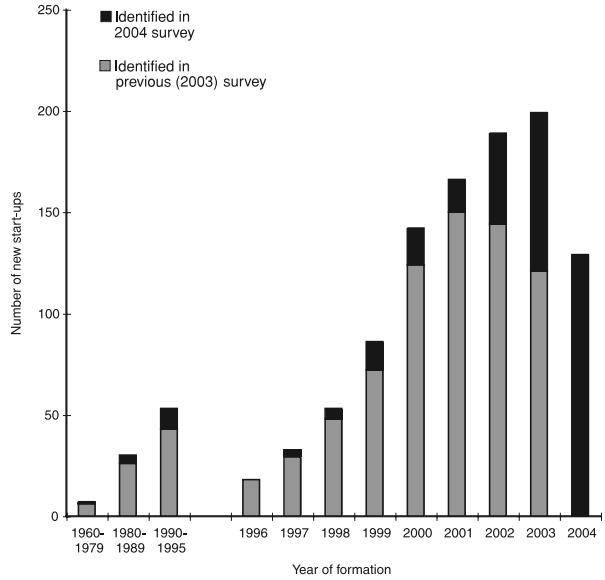

Figure 2. Japanese university start-ups in 2004 by year of formation.

Source: METI (2005). Reproduced by permission.

Although the 1998 TLO law neither changed this ownership system nor established a system to verify professors' assertions as to sources of funding, it legitimized the negotiated transfer of IP rights to industry. This was especially valuable for university start-ups. It is no coincidence that the number of university start-ups shows a marked increase after 1998, which was accelerated by the 2000 Law to Strengthen Industrial Technology that enabled university researchers to consult openly for companies and to manage start-ups (see Figure 2).[18]

Current status

The 2004 National University Incorporation Law is the keystone capping this entire process. It finally makes the entire technology transfer system coherent, rational and transparent. One might expect that this would lead to a further surge in start-up formation and increased transfers for university discoveries to new companies, but this has not been the case, except perhaps in the life sciences.[19] The reasons why Japanese science and technology start-ups are still struggling and play a negligible role in innovation (except, to some extent, in biomedicine and software) are complex and are the subject of Kneller (2007). One likely reason is that large companies continue to pre-empt a significant proportion of university discoveries. They are doing so via joint research agreements, joint research being the principal contractual mechanism for universities and private companies to cooperate on R&D.[20]

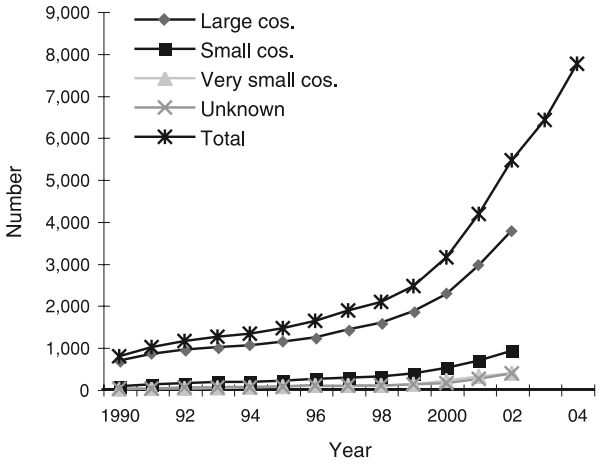

Figure 3. New and ongoing joint research projects between private companies and national universities.

Note: Large companies are defined as those with over 300 employees, small companies as those with 21–300, and very small as those with up to 20 (except in the case of retail and service businesses, for which 'very small' is defined as no more than five employees). Most start-ups would fall into the very small category in their first years of business.

Sources: The 1990–2002 data are from Nakayama *et al* (2005). The 2003–04 data are from MEXT (2005), which does not give a breakdown by company size.

Joint research and pre-emption

Nationwide data on joint research

Figure 3 shows that joint research has increased dramatically beginning around the start of the IP ownership reforms, and projects with large companies still account for 70% of all projects, a proportion that has been declining only gradually since the 1990s.

Data collection

I was kindly allowed to attend the weekly invention review sessions of the TLO of a large national university. Documents summarizing each reported invention identify the inventors and their affiliations, as well as whether they arose under a commissioned or joint research contract. Between February and July 2005, I attended thirteen of the weekly review sessions. During these sessions, 143 invention reports were reviewed, for an average of 11 per week or about 550 per year. I tried to understand the essence of each invention, and on this basis I classified inventions according to whether they were life science, engineering (including instruments and IT-related hardware), chemicals/materials (including many nanotechnology inventions) or software. Often an invention combined two of these fields, in which case I assigned it half to one field and half to the other. In the case of inventions made under sponsored research agreements or with industry co-inventors, I classified the companies according to size[21] and whether they were start-ups in the sense of being based on university discoveries. I have continued to monitor invention reports and to classify them in the same manner. As of May 2006, with more than 150 additional observations, the distribution of inventions among the various categories did not seem to have changed.

Results and analysis

Figure 4 shows that engineering and IT hardware account for the largest number of inventions, followed by life science, materials/chemistry and software.[22]

Thirty-one per cent of the inventions were attributed to joint research contracts with private companies. In this university, joint research accounts for less than 6% of total project-specific research funding.[23] The remainder were nearly equally divided among those with inventors from a single academic laboratory or department and those with inventors from two or more departments or two or more universities. The association between co-inventorship and inventions attributed to joint research is tight. In this sample, only one of 45 joint research inventions did not have co-inventors, and all inventions with industry co-inventors arose under joint research agreements. Thus, 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. I do not know how carefully claims of co-inventorship are scrutinized by the patent attorneys who file applications. However, discussions with TLO personnel and university and industry scientists suggest that most joint research projects do involve frequent in-depth interactions between university and industry researchers,

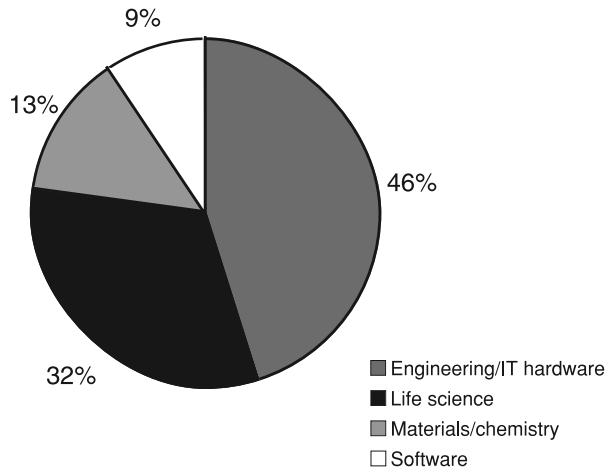

Figure 4. Inventions by field.

so many claims of co-inventorship probably are legitimate.

The fact that about half of the non-joint research inventions are the results of cross-laboratory, often interdisciplinary collaborations is a new phenomenon. Prior to 2004, the great majority of inventions submitted to the TLO represented the work of a single laboratory. However, as the reforms have progressed and invention disclosures have increased, there has been a corresponding increase in the proportion of inventions arising from collaborations between different laboratories, often in different fields of science or different universities. Rising awareness of the commercial potential of research has probably stimulated collaboration across institutional boundaries, at least in this university.

Among the 46 life science inventions, only 18% arose under joint research. Of these, only one-third were attributed to joint research with large companies – the remainder to joint research with university start-ups or other small companies (Figure 5).[24] 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 significant proportion of university research results. The TLO is free to license most life science inventions to those companies it determines are most willing and able to develop them, including start-ups if they exhibit the right combination of entrepreneurship, funding and market opportunity. Indeed, life science start-ups account for half of this university's total number of start-ups – and are by far its strongest according to various standard business indices.

However, in the case of inventions outside the life sciences (most of which are IT or materials/chemistry related) nearly 40% were joint, and more than 80% of these were with large companies (Figure 6). The TLO is free to license a smaller proportion of these inventions to other companies or to start-ups. Thus the likelihood that large companies are pre-empting university

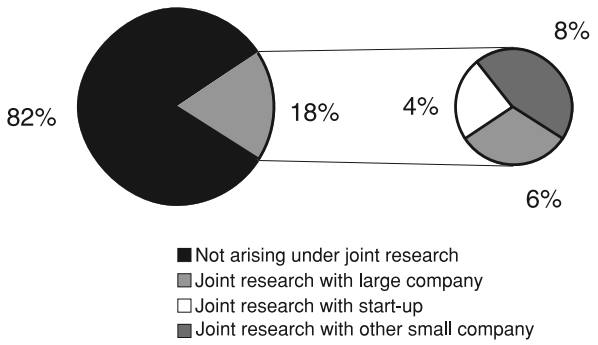

Figure 5. Life science inventions.

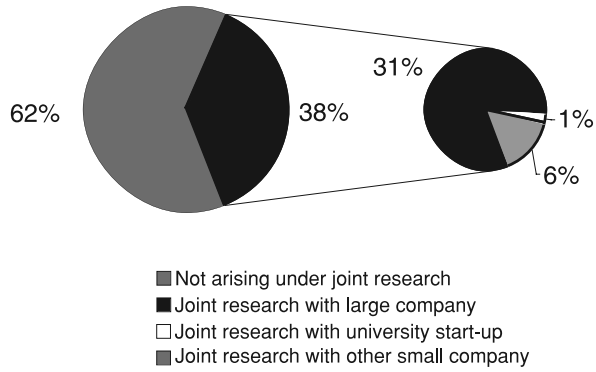

Figure 6. Inventions outside the life sciences.

research in these fields is higher. In fields other than the life sciences, large companies are probably using joint research contracts in the same way they used donations under the old system to appropriate a large amount of publicly supported research.

One limitation of this analysis is that it deals with invention reports, not patent applications – much less issued patents. Overall, this TLO files Japanese patent applications on roughly 30–40% of the reported inventions. Reasons for not applying for patents on the other 60–70% include doubts about patentability, low market potential and immaturity of the invention. However, among the subset that are joint research inventions, the rate of patent applications is higher, probably around 60–70%.[25] Thus, in terms of inventions on which applications are filed, joint research inventions probably account for about half of the total filings and represent a majority of inventions outside the life sciences. Therefore, Figures 5 and 6 underestimate the frequency of pre-emption.

Another limitation of this analysis is that it deals with only one university. However, a colleague responsible for technology transfer in another major national university has informed me that 46% of the invention disclosures in that university arise under joint or commissioned research agreements. Most of these were in engineering and materials/chemistry, and just over half involved large companies. Small companies (most of which happen to be regional and outside the Kanto and Kansai metropolitan areas) are benefiting more from joint research with this university than with the university I surveyed – but probably still not as much as large companies. Indirect accounts from the technology management staff in about fifteen other Japanese universities suggest that, in these universities, the average proportion of joint research and commissioned research inventions is also 40–50%. There are anecdotal accounts of even higher rates in other universities.[26]

Discussion and conclusion

These findings are not necessarily negative. Economic pressures are forcing many Japanese companies to rely more on collaborative research with universities than on basic research in their own laboratories (*International Herald Tribune–Asahi Shinbun*, 2004). Increased university–industry collaboration via joint research may be the key to allowing Japan's established companies to regain a competitive international edge in innovation. Many universities have good researchers but weak TLOs. In these universities, joint and commissioned research is the only effective mechanism of technology transfer – at least if start-up formation is not feasible because of lack of venture capital, management expertise and markets. Also, well-known professors often engage in joint research with several companies, even from within the same industry. So, while pre-emption by established companies as a group may be of concern, pre-emption by individual companies is probably less so. Finally, the frequency of joint research may reflect lower institutional barriers to university–industry cooperation than in the USA. Industry-sponsored inventions probably constitute less than 10% of the total among US universities, and only a small fraction of these have industry co-inventors.[27] Thus Japanese companies and professors may seek collaborations with each other more readily than their US counterparts – although any comparison must also take into account consulting and the formation of start-ups.

Finally, the TLO whose data are analysed in this paper is handling the overall technology transfer process well, consulting closely with inventors, making timely decisions as to 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 start-ups in the country). This university has shown that, despite the pre-emption by joint research of a large proportion of discoveries, promising opportunities for licensing and start-up formation remain.

But if the new system is basically a continuation of the old, does it offer any benefits to Japanese industry and innovation compared to what existed before? Can it be the basis for a Japanese industrial revival?

From my vantage point in a major university, the number of industry researchers on campus is noticeably greater than eight years ago. Nationwide, the numbers of company researchers engaged in joint research in universities doubled over ten years to nearly 3,000 in 2002. This seems to suggest a closer level of university–industry cooperation than occurred under the old system, although the rise in the numbers of company joint researchers actually predates the IP ownership reforms.[28]

However, having so many of the best 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. Co-ownership still entails automatic, royalty-free, non-transferable, exclusive rights to the invention.[29]

Furthermore, the prevalence of joint research raises questions about a shift in focus from fundamental to applied research in universities.[30] 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 to the next generation of new products? 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. [31]

Of course, start-ups also make use of the joint research system. In the long run, as a result of government policies and social changes, more new companies will probably engage in joint research. However, if the start-ups 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 offers established companies.

Much is unknown about the advantages and disadvantages of a Japanese-style system of technology transfer dependent largely on joint research and a US-style system in which universities negotiate aggressively with existing companies and universities and companies (start-ups excepted) tend to keep each other at arm's length. As a first step, there should be cross-national comparisons of:

- the prevalence of joint research in various fields of technology;
- the mix of large versus small company participants in joint research projects;
- how university and company joint researchers interact; and
- specific benefits to companies, academics and students.

Surprisingly, little information seems available on these issues. Of course, even if clear differences and advantages are found, various factors constrain the feasible changes for either system.

Nevertheless, on the basis of such studies, US universities might consider whether and how they might encourage the close sort of collaboration that now exists in some Japanese university laboratories.

At the same time, Japan should consider the potential conflicts between the goals of supporting existing companies, encouraging the formation of new companies and promoting high-quality fundamental scientific research in its universities. In particular, it should be careful that the last two goals are not sacrificed for the first. In addition, considering the prominent role that start-ups have played in early-stage innovation in the USA, it should try to level the playing field with respect to access to university discoveries for established companies and start-ups.

The following are a few measures that might help in this regard:

(1) Make identification of technologies appropriate for start-ups and liaison with outside venture capital a priority mission for the TLO.
(2) Ensure close coordination between the TLO and the university office managing joint research contracts.
(3) Ensure that the scope of joint research protocols is clearly defined and commensurate with the company's research support.
(4) Verify claims of co-inventorship and attributions of inventions to joint research projects.
(5) Eliminate the remaining barriers to national universities taking equity from start-ups in lieu of cash royalties for licences.
(6) Either eliminate the provision in article 73 of Japan's patent law that requires agreement of all patent co-owners to any licence, or require a bypass of that provision that cannot be overridden 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.
(7) Currently, uncertainty over conflict-of-interest issues is a serious barrier to productive relations between universities and start-ups. To provide clarity and flexibility, leading universities and government laboratories should employ on a long-term basis at least one or two people with interdisciplinary expertise to be responsible for managing conflicts-of-interest and research-subject-protection issues. They should have authority to make decisions on a case-by-case basis and (in consultation with government ministries) to evolve procedures that ensure the safety of research subjects (particularly in clinical trials), scientific integrity and the paramountcy of academic goals, while at the same time promoting the commercialization of university discoveries and maintaining a supportive environment for start-ups.

Even these narrowly focused measures will require concerted involvement of universities, their faculties and their TLOs, and consultation with government agencies and the wider business community. If Japan is to become a more hospitable overall environment for ventures, there will need to be changes that go beyond levelling the playing field with respect to access to university discoveries – changes that address issues of labour mobility, investment incentives and the willingness of large companies to work with independent small companies.

In light of all these problems, do the 1998–2004 reforms make sense? Would it have been better not to change the system? Unless it is fairly clear that Japan does not need high-technology start-ups, the reforms were necessary and any alternative system would be worse. Japan's experience with a system of national ownership of university IP under which exclusive licensing is difficult and bureaucratic shows that a return to such a system would inevitably result in faculty and companies bypassing it in a way that thwarts start-ups and leaves development of university discoveries mostly up to large companies. A system that lets inventors retain ownership would give start-ups and other small companies more access to university discoveries, but under present circumstances it would probably still result in most inventions being channelled to large companies, or not being developed at all. In the near term, developing an environment that encourages start-ups will depend largely on TLOs and supportive university administrations. Unfortunately, many TLOs are still short of resources and face steep learning curves, and all must claw back ground (both in terms of technologies and credibility among academics and the business community) ceded to the practice of pre-emption of university discoveries by joint research.

Notes

[1]The article presents data to support the hypothesis of pre-emption by joint research introduced in an earlier article (Kneller, 2005).
[2]This was the effect of the National University Corporation Law [Kokuritsu daigaku houjin hou] (No 112 of 2003).
[3]Article 35.
[4]The official title of the 1998 TLO law is the Law to Promote the Transfer of University Technologies [Daigaku nado gijutsu iten sokushin hou] (Law No 52 of 1998). The other two laws were the 1999 Japanese Bayh–Dole law, officially the Law of Special Measures to Revive Industrial Vitality [Sangyou katsu-ryoku saisei toku-betsu sochi hou] (Law No 31 of 1999), which applied to universities only once they became independent legal entities in April 2004, and the 2000 Law to Strengthen Industrial Technology [Sangyou gijutsu ryoko kyouka hou] (Law No 44 of

2000), which streamlined procedures and regulations related to sponsored research and enabled academics to consult for companies and even to assume managerial positions. For details, see Kneller (2003).

[5]See the section on start-ups and also Kneller (2003).

[6]As of April 2005, there were thirty-nine government-approved TLOs that had received subsidies for at least the first five years of their existence. There were also thirty-four IP management offices (also known as 'IP headquarters') in various higher education institutions, also government-subsidized. See Kneller (2004).

[7]At least this is the case in the University of Tokyo, which often serves as a model for other universities.

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

[9]Japanese data in this paragraph are from METI (2005) and various unpublished METI summary data sheets.

[10]Data from the *AUTM Licensing Survey FY1991–FY 1995*: 109 US universities, academic medical centres and patent management organizations gave numerical responses to the 1991 AUTM Survey on the number of US patent applications, for an average of fifteen applications per respondent. (AUTM is the Association of University Technology Managers.)

[11]Data on the number of licences issued each year 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 licences, for an average of 1·9 million yen ($17,000) per licence. As of September 2003, the 35 approved TLOs had *cumulative* royalty income of 107 million yen from 619 licences that had ever earned royalties, for an average of 1·73 million yen ($15,700) per licence, suggesting that over most of 2003 average annual royalties from royalty-earning licences did not increase substantially (data from METI).

[12]Total 2004 royalty income was 2,904 million yen, all but 412 million yen of which was earned by one TLO. One dollar is equivalent to about 110 yen. Elsewhere in this paper I use 10^8 (1 oku, in Japanese) as a unit of measure for yen, which corresponds roughly to $1 million.

[13]According to the *AUTM US Licensing Survey: 2004 (Survey Summary)*, $218 million is the gross licence revenues of universities, academic medical centres and technology management corporations net of inter-university licence transfer payments.

[14]Regarding this latter point, a few TLOs have managed the change very well and have year-on increases in invention disclosures, patent applications and royalties. But even some strong TLOs have encountered problems. Many universities without strong TLOs are essentially building their invention management capabilities from scratch. As in the USA, one of the determinants of TLO success is the ability to recruit competent staff, especially people who can network well with companies and university scientists. See Owen-Smith and Powell (2001).

[15]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 (2003).

[16]Almost all donations were less than 5 million yen (or approximately $40,000). They sometimes served as a means of technology monitoring, but sometimes they supported research important to the donors' core businesses.

[17]In some cases this uncertainty was partially dispelled by a declaration of the university's Invention Committee that an invention belonged to the inventor rather than to the government. But these decisions almost always relied on the inventors' assertions as to sources of funding, hardly ever on an investigation by the Invention Committee into the actual sources of funding.

[18]These data should be interpreted with caution, although I believe the general trend is accurate. The government announced a goal of 1,000 university start-ups by mid-2004 and there was pressure to indicate that these goals were met. The totals in Figure 2 include not only start-ups directly based on university discoveries but also companies with other 'close' ties, such as executives/founders who are recent graduates and other new companies that have engaged in joint research with the university. An analysis of the start-ups from the University of Tokyo, Keio University and AIST indicates that some of these ties are not close and that probably the most appropriate definition of a start-up is a new company based directly on one or more discoveries from a university. Using this definition, the totals should be discounted by about 40%. However, many of the remaining start-ups are little more than virtual companies, with low sales, low capitalization, few employees and a limited technology/IP base. So a more appropriate discount factor would be at least 50%. This analysis is described in Kneller (2007).

[19]This is based partly on the trend suggested by Figure 2 and the preceding note. Also I have updated lists of Keio and University of Tokyo start-ups which do not show an increase in the rate of start-up formation for 2004. Discussions with TLO personnel and analysts in private investment organizations together with my own observations from the University of Tokyo indicate that, while there continues to be a steady (perhaps increasing) stream of start-up formation in the life sciences, there has been no increase (and more likely a reduction) in start-up formation in other technical fields.

[20]The principal difference between joint research and commissioned research, the other contractual mechanism for R&D cooperation, is that company researchers can work in university laboratories under the former but not the latter. As described below, this distinction is important, because it provides an opportunity for company researchers to become co-inventors, and thus for their companies to have automatic co-ownership rights. Funding for commissioned research is greater than for joint research, but about 95% of commissioned research is sponsored by government agencies, including government-owned corporations.

[21]I classified companies with more than 300 employees as large, and those with up to 300 as small.

[22]The proportion of life science inventions is probably slightly lower than the proportion of research resources devoted to life sciences in this university, where about 38% of the graduate students are in life science fields, and 31% to 47% of commissioned research funds went to life science departments, including the medical school.

[23]Official 2005 data for this university.

[24]Unlike many US universities, most Japanese universities permit joint and commissioned research between a start-up and the founder's laboratory.

[25]These inventions are usually applied for jointly, with the companies paying a substantial proportion of the application costs. This is important for the majority of TLOs, which face tight budget constraints.

[26]Another source indicated that nearly 100% of reported inventions in a major Japanese private university arise under joint or commissioned research agreements with companies.

[27]Communications with US technology transfer officials in 2005.

[28]In 1992 there were 1,398; in 2002, 2,821. See MEXT (2005). Unlike the number of joint research agreements that show a clear upward inflection point between 1998 and 2000 coinciding with the beginning of the reforms, the number of company joint researchers has been increasing more or less linearly since the 1980s. 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*.

[29]See the discussion of universities' largely unsuccessful attempts to bypass article 73 of Japan's Patent Law above at the end of the summary of the 1998–2004 reforms. Also, on occasion, a company whose employees are listed as co-owners will declare it is not interested in applying for patents – nor in transferring its co-inventorship rights to the university. In other words, the company wants the invention treated as a trade secret, never to be disclosed in a patent application or an academic journal. Although such cases are not common, when they arise the university is generally unwilling to defy the company, especially if the company is interested in the technology.

[30]According to Organization for Economic Cooperation and Development statistics, industry funded only 2·5% of Japanese university R&D in 2000, compared to more than 7% in the USA (National Science Board, Science and Engineering Indicators 2004). However, as described in Kneller (2007), this comparison probably underestimates the emphasis on applied research and the influence of Japanese companies in Japanese universities.

[31]This argument and its implications are developed in Kneller (2007).

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