# 3

# Upholding the Pecking Order: Universities and Their Relations with Industry

## INTRODUCTION

Universities are the origin of many high technology ventures. In this book I use the term *startup*, specifically to refer to ventures whose core technology at founding is directly based on university discoveries.[1] More broadly, universities are the origin of many discoveries that become the basis for innovative new technologies, whether developed by old or new companies. However, the degree to which university research is the proximate origin of innovation is difficult to determine. There is variation by country and industry, as suggested in Chapter 1. In the USA, innovation in pharmaceuticals and other fields of biomedicine draws heavily on university research. About one-quarter of all new US-origin drugs are discovered in US university laboratories.[2] The contributions of UK and Canadian universities are equivalent, but in Japan and the major Continental European countries, this proportion is much lower.[3] US patents on biomedical inventions cite academic papers more than patents in other fields—suggesting that such inventions draw on academic research more than US patents in any other field, IT being a distant second. In both the case of biomedical and IT-related patents, there is an increasing trend over time to cite academic research—suggesting that university research is becoming more important for innovation, at least in these fields.[4] Biomedicine and IT are the two main growth areas in the US economy in terms of sales and employment.[5]

The proportion of high technology ventures that are university startups is also uncertain. Biotechnology is considered to be an industry based on close university–bioventure linkages.[6] However, a survey of US biotechnology companies conducted in the late 1980s showed that just under half of the founders came from academic positions, only slightly more than those that came from other companies. Also, the trend was for founders to come increasingly from industry, so now the proportion of bioventures founded by university researchers may be considerably less than half.[7]

About three-quarters of Japanese bioventures that are oriented toward developing therapeutics are based on university discoveries. Thus in Japan, bioventures are probably at least as dependent on universities as their US counterparts.[8]

As for IT and other nonbiomedical fields, most US venture companies whose business is focused on integrated circuits or computer hard disk drives are formed by persons leaving existing companies. Few are based directly on university discoveries.[9] However, in some other technologies discussed later in this book, for example, tunable lasers for optical switching devices, gene sequencers and nanotechnology/materials science in its various applications, university startups seem to be among the innovation leaders in the USA—although not in Japan.

In summary, universities are not the fountainheads of innovation in all fields of technology. However, they may have a disproportionate influence on innovation in the most dynamic areas of the economy, and in many cases, initial commercial development of university discoveries in these areas may depend on startups.

Part I of this chapter shows how, until recently, the Japanese system of university–industry technology transfer impeded the formation of startups. Recent reforms have improved the environment for academic collaboration with large and small companies alike. Although the legal framework governing technology transfer from universities to industry is now amenable to startup formation, the system still favors transfer of university discoveries to large rather than new companies.

Part II shows how other institutional and social factors, for example career paths in academia, the system of research funding, and uncertainties related to conflicts of interest, also contribute to an environment more suitable for large companies than for startups.

## PART I: UNIVERSITY–INDUSTRY TECHNOLOGY TRANSFER

### Overview of Technology Transfer in Japan and the USA

Because ownership and management of intellectual property (IP) is central to how university discoveries are transferred to industry, this part begins with an overview of how the system of university IP ownership has changed. Prior to 1998, either the government or the individual inventors owned inventions made in Japanese universities, depending on the source of funding that gave rise to the inventions. In a series of legal reforms between 1998 and 2004, this system of ownership changed to a system under which universities may own all inventions made by their faculty, and indeed are encouraged to do so.

The new Japanese system of ownership is similar to the system in the USA since 1980. That year the Bayh-Dole amendments to US Patent Law[10] gave universities the right to own inventions arising under R&D funded by agencies of the US government. Prior to 1980, the government funding agencies had the right of ownership. Because US government funding accounted for about 67 percent of R&D support in US universities during the 1970s,[11] a roughly equivalent proportion of university discoveries were probably subject to government ownership. Being subject to the government's right of ownership meant that it was difficult for any of these inventions to be licensed exclusively. With a few exceptions, US government agencies did not have authority to issue exclusive licenses until 1971.[12] But even after 1971, until the passage of the Bayh-Dole amendments, the number of exclusive licenses covering university inventions issued by government agencies was small. In the case of the US Department of Health Education and Welfare (DHEW), which had pushed hardest for mechanisms to permit exclusive licensing, the number of exclusive licenses issued between 1969 and 1980 was less than twenty.[13] The more important mechanism for licensing DHEW-funded university inventions were *institutional patent agreements* (*IPAs*) that DHEW began to sign with US universities in 1968. Under a typical IPA, a university that showed it was able to manage IP and abide by applicable laws could take title to DHEW funded inventions and then license them to industry. Exclusive licenses were possible, but only for terms so limited they would probably not meet the needs of startups.[14] By 1977, DHEW had seventy IPAs in effect covering most leading US universities. NSF began to conclude IPAs in 1973. Nevertheless, by the mid-1970s, the number of exclusive licenses issued by universities under IPAs was still under 100.[15]

The pressures to grant exclusive licenses to university inventions were greatest in the case of NIH funded inventions relating to pharmaceuticals.[16] Exclusive patent rights are important for pharmaceutical development, because the process is long and expensive and even late in the human trials a candidate drug may turn out to be a failure. But after safety and effectiveness have finally been shown, the main chemical constituents of drugs are usually easy to copy. Nevertheless, some of the support for universities' authority to license exclusively under Bayh-Dole came from outside the pharmaceutical industry.[17] In addition, startups in most industries need exclusive licenses in order to be able to attract private investment necessary for growth and to have some bargaining leverage to get to the negotiating table with other companies, especially to convince larger companies to become their customers.[18] One of the earliest examples of a university granting exclusive licenses involved an electronics startup financed by one of America's first venture capital firms, that together argued the company could not be formed without protection from encroachment.[19]

Founded in 1976, Genentech has been one of the first successful university bio-startups that drew heavily on university research even after its founding.[20] Part of its early business strategy involved obtaining exclusive rights to university inventions, even prior to Bayh-Dole.[21] Between the founding of Genentech and the passage of Bayh-Dole, a few other bio-startups were founded, and then in 1981 the number of new bioventures jumped to nearly threefold the number formed the previous year.[22] This suggests that the liberalization of policies governing the issuance of exclusive licenses to government funded university inventions improved the environment for new company formation and may have been a necessary condition for the rise of university startups in biomedicine and even other fields.

The same link between liberalizing government restrictions on exclusive licenses and the rise of startups is evident in the case of Japan. Nevertheless, in the years before Japan liberalized restrictions on formal exclusive licenses, its system of technology transfer differed greatly from that of the USA. It was an informal system that gave no scope to academic entrepreneurship, but which made the transfer of exclusive rights to university discoveries to established companies extremely easy. When the framework became similar to that of the USA, this was not sufficient to make new company creation a principal mechanism to develop university discoveries. Instead, the patterns of university–industry cooperation established during the postwar decades accommodated to the new legal framework and persisted. Except in biomedicine, large established companies remain the main channel for commercializing Japanese university discoveries. The very closeness of links between large companies and leading university laboratories forecloses opportunities for new companies to grow.

## The Pre-1998 Japanese System[23]

Similar to postwar America, in Japan there was a presumption that inventions made in *national universities*[24] belonged to the nation and should be freely available for all to use or licensed nonexclusively by central government bureaus. However in the 1970s, just as in the USA, corporate interest in university research and in securing formal IP rights to university discoveries created pressures to make the system of IP management more flexible. The solution implemented in 1978 (two years before Bayh-Dole) was to retain government ownership over all inventions arising under project-specific funding, but to let university inventors retain ownership over inventions arising from *non-project-specific funding*. The former includes funding under *formal sponsored research agreements*[25] and *government grants-in-aid* for research. The latter includes nominal *standard research allowances*[26] available to all full-time faculty engaged in research and, most importantly, *donations* from corporations or individuals.

Project-specific funding accounted for a majority of funds available for discretionary research expenditures,[27] and thus more than half of university inventions probably should have been classified as national inventions. In fact, probably less than 10 percent of inventions were classified as national inventions, and most of these were jointly owned by the corporate sponsors of formal collaborative research.[28]

Why and how did this happen? National ownership entailed management of the patent applications by government bureaucracies and nonexclusive licensing.[29] Therefore, companies considered this designation undesirable. On the other hand, donations were attractive to faculty 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.[30] Even today, donations remain the main source of corporate support for university research.[31]

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 after graduation. Donations were an important mechanism to sustain university–industry cooperation between the end of World War II, when formal consulting was banned and other types of formal cooperation restricted,[32] until the 1998–2004 reforms that once again opened the door to formal, transparent forms of cooperation. To keep their side of the bargain, faculty inventors also wanted to avoid the national invention classification. Also most faculty inventors thought that the government bureaux did not manage their inventions competently, and that direct transfer to collaborating companies offered the best means of development. Attribution of invention funding was easily manipulated.[33] Except for inventions arising under formal sponsored research agreements with companies,[34] almost all commercially useful inventions were attributed to donations (less frequently, to the standard research allowances)—when in fact, many benefited from project-specific government funding.[35] Thus, donations and officially tolerated misattribution of funding sources 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. 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 on university discoveries in this field.[36]

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. The origins of pipeline drugs discussed in Chapter 2 suggests that the numerous collaborations of the large Japanese pharmaceutical companies with university researchers usually involved basic science issues or narrowly defined research tasks and rarely led 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. One of the most successful Japanese biostartups had to license back the founder's inventions from Japanese pharmaceutical companies that had obtained ownership under the informal technology transfer system.[37] 'Sleeping university inventions' unused by companies was a key concern of the government agencies that promoted the 1998–2004 reforms.[38] Government advisory committees that recommended adopting a US-style system reasoned that ownership would give universities incentives to manage their own inventions so as to maximize their commercial and societal value.[39]

The system was disadvantageous to small companies, especially startups. Inventions that might have provided the bases for strong startups were sometimes transferred unwittingly or automatically to companies that gave donations. Small companies could not compete in terms of the numbers of laboratories to which they could give donations. 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.[40] Startups were additionally handicapped because uncertainty over invention ownership could discourage private investment. However, promotion of startups was not a main goal of the reforms, nor was there much discussion to the effect that clarity of ownership and formal technology transfer mechanisms are especially important for startups.[41]

In addition, personnel regulations prohibited consulting and holding a management position in a company. Only in 2000, when such activities were legalized, did national university professors begin to establish companies.

Finally, 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. Their administrative staffs were MEXT bureaucrats who changed jobs every two years, sometimes moving to another institution. Today administrative staff still rotate regularly, but they usually remain within the same university. Overhead payments are higher, but they mainly are plowed back to directly support research in the laboratory or department/center that received the funding. Receiving stock in lieu of cash for license royalties is still problematic for national universities. For these reasons and others, Japanese universities *as institutions* remain less entrepreneurial than their US counterparts. Their direct financial interest in the success of their startups is still less.

## Legal Convergence Masking Continuing Divergence

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

- The 1998 *Law to Promote the Transfer of University Technologies*[42] (the *TLO*[43] *Law*) legitimized and facilitated transparent, contractual transfers of university discoveries to industry, even though it did not change the basic ownership system. It provided a fig leaf to allow contractual licensing of inventions to industry, even though a rigorous analysis of funding sources might have revealed that inventions arose under project specific government funding. It also provided for subsidies of about US$ 180,000 annually for five years for approved TLOs.[44] Starting from five TLOs approved in 1998, the number of approved TLOs increased to thirty-nine by the end of 2005.
- The 1999 *Law of Special Measures to Revive Industry*[45] (the *Japan Bayh-Dole Law*) has the same effect as US Bayh-Dole Law, *except that it did not apply to national universities until they obtained legal status as semi-autonomous administrative entities in 2004.*[46]
- The 2000 *Law to Strengthen Industrial Technology*[47] permitted national university researchers to engage in paid outside work on behalf of corporations. Implementing regulations and university policies were progressively relaxed until about 2005, at which time a wide range of consulting and even management activities were permitted. However, permission for a national university faculty member to hold an outside management/directorship position is granted only if the outside work

is directed toward the commercializing of the researcher's own university discoveries, and such high level positions require a higher level of approval within the universities.[48]

Also, the Law to Strengthen Industrial Technology streamlined the procedures for company-sponsored commissioned and joint research. It cleared away bureaucratic barriers to the flow of funds under these formal research agreements.[49] In so doing, it paved the way for using sponsored research funds to pay stipends for graduate students and postdoctoral researchers and for the expansion of formal joint research agreements, the most important feature of the current technology transfer landscape.

- The *National University Incorporation Law*[50] 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 universities to assert ownership over commercially valuable inventions.[51]

With the last of these reforms, the legal framework of Japan's technology transfer system came to resemble closely that of the US.

Many standard indices of technology transfer activity compare favorably to US indices. Average patent applications per TLO were higher than historical US averages.[52] Average numbers of licenses were also higher.[53] However, average royalties are probably considerably lower than historical US levels.[54]

As for startups, the numbers being formed each year are impressive and their rise coincides closely with the 1998 and 2000 reforms that facilitated exclusive licensing and consulting.

Figure 3.1 should be interpreted with caution, although the general pattern is probably accurate. It includes companies whose only connection with universities is having engaged in joint research, or having graduates or faculty as advisers, investors or managers (but not founders). It also includes limited liability companies whose operations and business scope are small, as well as companies that seem to be focused only on sales or provision of services. In order to adjust these figures to represent companies that are *based directly on university discoveries*, the totals for each year should probably be discounted by about 40 percent.[55] Also my conversations with TLO and investment personnel indicate that the leveling off in the formation rate is a real phenomenon, and outside of biomedicine, the rate of startup formation is probably decreasing.

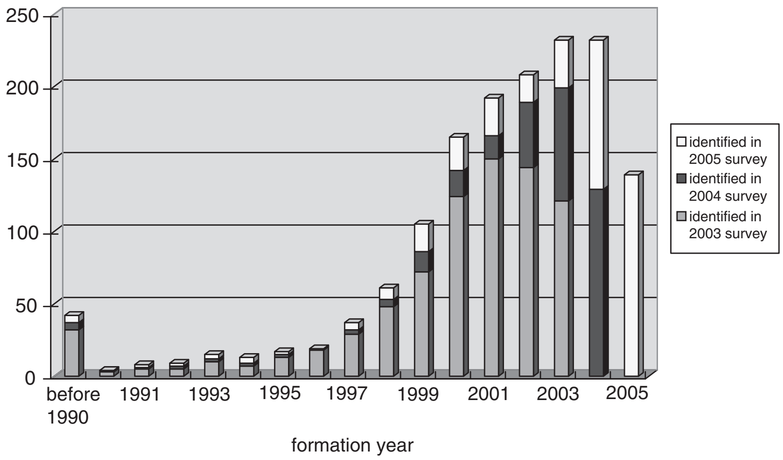


**Figure 3.1.** Number of Japanese startups formed per year
*Source*: METI (2006).

But even applying a 40 percent discount factor, the rate of startup formation is quite respectable in comparison with startup formation in the USA in the early years following Bayh-Dole. In the 1980s, rates of startup formation were probably well under 100 per year, and had only risen to around 200 per year about 14 years after Bayh-Dole.

Nevertheless, Figure 3.1 masks general weakness and difficulty to compete with established companies for access to the most important university discoveries. As discussed in Chapter 4, aside from some startups in biomedicine and a smaller number in software, most of these startups are small in terms of sales, employees, and capital, and their core technologies offer little prospect for business growth. Even in life science, the average size of the start-ups is less than half the size of US bioventures of equivalent age based on historical data.[56] Japanese bioventures (most of which are start-ups) have not been able to grow as fast as their US competitors and total sector employment is considerably less than in the USA.

The reasons for this weakness is one of the main themes of this book. However, several reasons relate specifically to the technology transfer system. 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. Thus some startups tend to focus too much on scientific issues and not enough on business goals.[57] In a similar vein, various government programs encourage startup formation without ensuring the startups are likely to produce products for which there is market demand. For example, JST

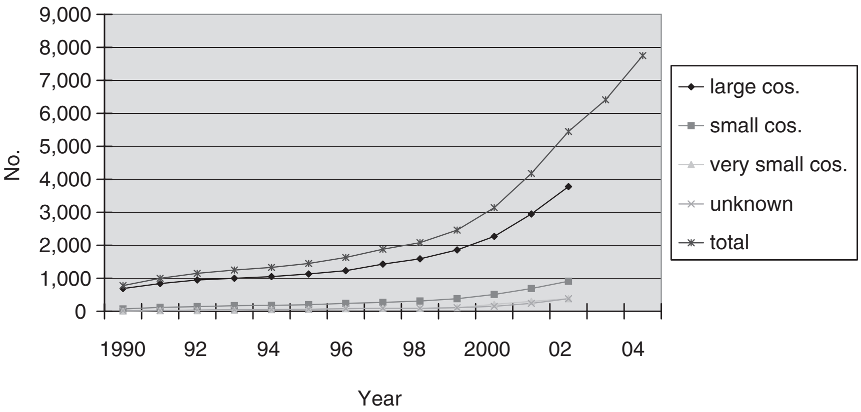


**Figure 3.2.** New and ongoing joint research projects between private companies and national universities
*Sources and definitions*: see note 60.

provides venture seed grants to university researchers on condition that they form a company within three years. Many recipients use these grants to pursue scientific projects, knowing it is easy to satisfy in a pro forma manner the startup requirement. (Japan's corporate law permits companies to be incorporated with just 1 yen paid in capital.[58]) But probably the main reason is that joint research with established companies has taken the place of donations, allowing established companies to preempt university discoveries and closing off technological niches that might otherwise have been available for entrepreneurial companies.

## Joint Research and the Preemption of University Discoveries

Figure 3.2 shows that joint research has increased dramatically beginning around the start of the reforms. As already mentioned, the 2000 Law to Strengthen Industrial Technology made joint and commissioned research more attractive mechanisms for companies to collaborate with universities. Projects with large companies account for 70 percent of all projects, a proportion that has been declining only gradually since the 1990s.[59]

Incorporation of national universities in 2004 meant that the universities 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 US 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 coinventors.

However, Japan's patent law favors 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 nonexclusive license. Thus, so long as the company is a co-owner by virtue of coinventorship 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, nontransferable, royalty free exclusive license.[61] 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 nonexclusive 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 nonexclusive licenses if that would put them in potential competition with a large company.[62] In addition, large companies sometimes insist that the bypass clauses be 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 usually pays most 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.[63]

I have been fortunate to have access to the invention reports submitted by university inventors to the TLO of a major national university. As shown in Figure 3.3, over a six month period in 2005, 46 percent of the inventions were in engineering or IT hardware, 32 percent pertained to life science, 13 percent to materials or chemistry, and 9 percent to software.[64]

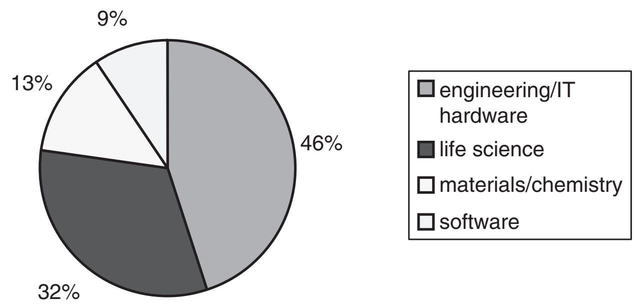


**Figure 3.3.** Inventions by field reported to one university

Thirty-one percent of the inventions were attributed to joint research projects with private companies, *although such projects account for less than 6 percent of activity-specific research funding in this university*.[65] In almost all these cases, a company researcher was also listed as a coinventor. 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 coinventor.

Only 18 percent 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.[66] 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 percent were joint inventions, and over 80 percent of these were with large companies. Thus, the TLO has management authority over a smaller proportion of these inventions. Figures 3.4 and 3.5 show this graphically: a small proportion of life science inventions are attributed to joint research and of this small proportion, 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 almost always a large company.

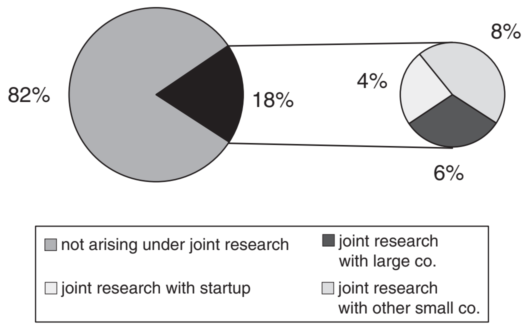


**Figure 3.4.** Life science inventions: association with joint research and type of industry partner

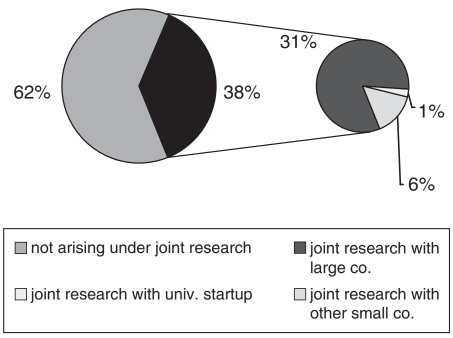


**Figure 3.5.** Non-life science inventions: association with joint research and type of industry partner

I have continued to monitor invention reports and as of the end of 2006 this general distribution has not changed.

This analysis deals with invention reports, not patent applications. This TLO files Japanese patent applications on roughly 30–40 percent of the reported inventions overall, but the application rate for joint inventions is 60–70 percent.[67] Thus, in terms of 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. Considering joint patent applications and licenses as the two main mechanisms for transferring university inventions to industry, in 2005 over 60 percent of such transfers by this TLO were the former type. In other words over 60 percent of transferred inventions were actually joint patent applications by the university and the joint research partner, probably giving the joint research partner a *de facto* exclusive license to the inventions in most cases) while less than 40 percent of the transferred inventions were owned entirely by the university and transferred as licenses (with the TLO playing a major role in deciding who should be the licensee). This confirms the dominant role of joint research and joint patent applications as the means of transferring this university's inventions to industry.

As for other universities, anecdotal reports from colleagues in 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.[68] From my vantage point in a major university, the numbers of industry researchers on campus is noticeably greater than eight years ago, an impression supported by nationwide data.[69] 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 its business goals, that is, more favorably than five to ten years ago.[70]

Industry sponsored inventions probably constitute less than 10 percent of the total among US universities, and only a small fraction of these have industry coinventors.[71] Thus, institutional barriers to cooperation between universities and established companies may be higher in the USA, and Japanese companies and professors may seek out collaborations with each other more readily than their US counterparts.[72] It has been suggested that US universities have focused too much on ownership of inventions and license revenue, whereas they ought to place more emphasis on the support that industry can provide for ongoing research.[73] Recent moves toward open collaborations in which companies support US university research in return for any resulting IP being freely available for academic and commercial use reflect this perspective.[74] But the big difference between open collaborations in US universities and joint research in Japanese universities is that, in the Japanese case, companies usually obtain exclusive IP rights.

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.[75] So while preemption by established companies as a group may be of concern, preemption by individual companies probably is less so. Finally, in 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 in 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 preemption by joint research of a large proportion of discoveries, promising opportunities for licensing and startup formation remain, but mainly in biomedical fields.[76]

On the other hand, having so many inventions flow automatically to established 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, and the undermining of core academic values. For example, the university of Tokyo's standard joint research contract (art. 30) obligates faculty to abide by the sponsoring company's reasonable requests to delete or change manuscripts related to the joint research. 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 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.[77] Even when an entrepreneurial professor manages to avoid initial preemption and starts a company based on innovative and commercially promising discoveries, the presence in his or her laboratory of large companies engaged in joint research often diminishes opportunities for the startup to grow, as described in Chapter 7.[78]

## Conclusions Pertaining to Technology Transfer

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 US 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 fifty biomedical startups and a smaller number of software startups that are making significant progress. But despite the legal framework being nearly identical to that in the USA, the Japanese system continues to favor transfer of university discoveries to large established companies. Weak nonentrepreneurial administrations coupled with the long-standing practice of faculty passing their discoveries directly to established companies have allowed joint research to take the place of donations in continuing a system of direct transfer of university discoveries from academic researchers to industry.[79] This benefits established companies but has hindered the formation of startups with strong growth prospects. Whether this contrast with the US system is beneficial for Japan's future depends on whether established companies are better at early stage innovation than new companies—whether Japan can dispense with new companies and rely on its established companies to carry forward early stage innovation in new fields of technology. These are complex questions that are deferred to Chapters 6 and 7.

At least the new Japanese technology transfer system opens alternative routes for university inventors to try to ensure their discoveries are developed. No longer do they have to rely on the large companies that provide them donations and hire their students—although, as noted in Chapter 7, it is often hard for inventors to exploit these alternatives (founding startups or licensing to outside companies) when working under the gaze of companies who have sent researchers into their laboratories.

The Japanese experience raises questions about the US system. Why did the US system evolve so that there was more separation between university researchers and established companies than in Japan? Why are faculty–company relations more at arm's length than in Japan? Turn the clock back to the 1920s and 1930s and it might seem that conditions were ripe for university–industry relations in the USA to evolve as they did in Japan. Consulting between faculty and companies was common, at least in MIT.[80] Also MIT attempted to entice industry to fund much of its R&D activities. These efforts were generally unsuccessful, although industry did welcome interactions, mainly as a means to recruit its graduates. These circumstances are similar to those in postwar and probably also prewar Japanese universities.

I suspect that part of the explanation lies in US universities being stronger institutional entities than their Japanese counterparts. MIT grappled with issues related to cooperation with industry in the 1920s and 1930s, and after back and forth consultations with its faculty developed policies on faculty consulting and on IP.[81] It took steps to establish an office to handle IP, and, most importantly, it set up an office to handle research contracts. Today, the contract office serves as a gatekeeper to MIT research. Corporate research sponsors do not have free rein to suggest to professors what percentage of inventorship on joint research inventions ought to be attributed to company researchers, as is currently common practice in Japanese universities. Instead, these offices scrutinize claims of joint inventorship closely and give the sponsors a limited period during which they can negotiate licenses.[82] Another factor was the large amount of government contract and grant research support in the postwar years, much of which was either defense or health related. This enabled universities such as Stanford and MIT to build world-leading research capabilities. Government funding also brightened employment prospects in academia for graduate students. Universities could resist attempts by industry to condition sponsored research funding on free and often exclusive access to wide swaths of university discoveries.

If these hypotheses are correct, they suggest both hope and caution for the entrepreneurial prospects for Japanese universities. The incorporation of national universities is a first step to enable them to build the institutional competence to manage their discoveries, not to let them pass, as through a sieve, to companies engaged in joint research. However, these competencies are being developed slowly.[83] Government funding has increased substantially over the past ten years, and much of this increase has been in the form of large contract research projects.[84] However, as discussed in Chapter 7, such funding often involves large company collaborators. Rather than helping universities to become independent institutions that can manage their resources, large-scale government funding has often perpetuated the pass through of university discoveries to established companies. Is this beneficial to Japan? Conversely, is the more formalized, arm's-length system of university–industry cooperation beneficial to America? The answer depends on the importance of vibrant, independent startups for early stage innovation.

Part II examines other institutional and social aspects of the Japanese university environment that influence faculty and student entrepreneurialism, particularly factors related to funding, career paths, and lack of clarity regarding the appropriate scope of academic entrepreneurship.

## PART II: INSTITUTIONAL AND SOCIAL FACTORS AFFECTING ACADEMIC ENTREPRENEURSHIP

If the door has been open to academic entrepreneurship, why are few academic researchers walking through it with the aim of creating strong, rapidly growing companies based on new technologies, or new applications of old technologies?[85] One reason relates to academic laboratories being under the gaze of joint research partners. Other reasons, to be discussed in subsequent chapters, concern difficulties ventures face in recruiting personnel. However, the remainder of this chapter discusses institutional and social factors related to universities.

### Uncertainty Regarding Conflicts of Interest

Faculty involvement in startups usually raises more issues regarding financial conflicts of interest, and often also conflicts of commitment of time and energy, than involvement in joint, commissioned, or donation-sponsored research. Startup formation usually requires that the faculty inventor be actively involved as an adviser. The normal mechanism to encourage and compensate this involvement is for the inventor(s) to hold a substantial proportion of the startup's initial stock. He or she may, in addition, be the principal member of the startup's board of scientific advisers, and in Japan, may even hold a line management position, such as CEO or chief scientific officer. In any case, in addition to being concerned about the scientific progress of the startup, she or he often will represent the startup to investors, the scientific community and the media. If the startup's R&D and business progress favorably, the increasing likelihood of an IPO or buyout raise the prospect of substantial financial benefit for the inventor. Although cooperation with established companies through donations or contract research also offer benefits in terms of increased funding for equipment, graduate students, and so forth and the prospect of eventual commercialization of one's discoveries, these usually do not compare to the complexity and public visibility of the conflict of interest and conflict of commitment issues that arise related to startups.

MEXT has permitted holding of pre-IPO stock in startups for several years. However, there has been little open debate about appropriate limitations or cautions related to stock ownership or other entrepreneurial activities. Moreover, conversations with journalists, university officials, researchers, and attorneys suggest that the concept, *conflicts of interest*, has a more negative connotation in Japan than in the USA. Rather than being regarded as an inevitable accompaniment to university entrepreneurship that requires management to avoid significant harm,[86] *conflicts of interest* appears widely regarded as a label of reprehension that ought to be avoided. Also, public perception is still strong that university faculty are public servants who ought not to be concerned about financial gain. Beginning about 2005, major universities began to require fairly comprehensive annual reporting of outside financial and business interests.[87] How this information will be used is not clear. The low threshold for public condemnation and the lack of open discussion on how to balance the conflicting objectives of promoting commercialization of discoveries and giving full priority to education and research create uncertainty about permissible limits of entrepreneurial behavior. The degree to which this discourages entrepreneurship and prompts university researchers to opt for collaboration with existing companies instead of forming their own startups is difficult to assess, but conversations with university researchers suggest it has an overall dampening effect.

Conflict of interest concerns are most acute in clinical trials of new drugs or medical procedures owned by a company in which a key university researcher has a financial interest. In such cases, patients' lives can be at stake.[88] In early 2006, a study committee funded by MEXT released unofficial guidelines that recommend comprehensive disclosure but leave the development of policies up to individual universities[89,90]. Several major universities have enacted official guidelines along similar lines.[91] Thus the institutional infrastructure is being developed to manage conflict of interest issues. But there is little open discussion about appropriate limits on faculty entrepreneurs participating in clinical trials, or specific procedures to protect patients and ensure the objectivity of publications. Anecdotal accounts indicate that some universities are adopting a strict approach that discourages faculty involvement in startups focused on clinical therapies, while others are adopting a liberal approach. In any case, debate on specific cases (if it occurs at all) appears to be limited to within small committees, and basic principles supported by specific, yet appropriately flexible, guidelines and management procedures are slow to be articulated, avoiding open discussion misses an opportunity to increase awareness among all parties (researchers, university administrators, businesses and the public) about the importance of conflicts of interest and how they can be managed responsibly.[92]

## Demographics

In relation to overall population, there probably are more researchers in US universities who can make discoveries in new fields that might be suitable for startups or who might become startup managers. Japanese companies still tend to hire bachelors or masters degree graduates for their R&D laboratories, and this limits the number of doctoral candidates in Japanese universities relative to what they would be in the US.[93] Nevertheless, on a per-population basis, the number of Japanese S&E doctoral graduates is approaching that of the USA.[94] The number of postdoctoral researchers is, however, much larger in the USA than in Japan.[95] The extent to which US high technology ventures recruit from the ranks of postdoctoral researchers merits further inquiry. America's advantage in S&E immigrants is discussed in the final chapter. Gender imbalances are considerably greater in Japan than the USA,[96] also suggesting lost opportunities to develop scientific and entrepreneurial talent.

## Kouzas

The basic organizational unit in Japanese universities is the *kouza*, modeled on the *professor chair* system in early twentieth-century German universities. A kouza typically consists of one full professor, the laboratory head, an assistant professor, who is usually the lead candidate to inherit laboratory leadership when the professor retires, and one assistant (*joshu*).[97] There is usually one laboratory per kouza. Thus laboratory facilities are under the kouza head. Applications for research funding from junior kouza members usually include the kouza head as a coapplicant, and of course must be coordinated with him or her.

In contrast, a new 30–40-year-old assistant professor in the USA is usually provided with his or her own laboratory, the startup costs for which may approach half a million dollars. The flip side of these benefits is that she or he is expected to obtain within two years competitive grants to cover not only laboratory costs but also a substantial proportion of his or her salary and the stipends for graduate students and postdoctoral researchers. Also within six years, his or her publications will have to pass muster before outside experts and a university committee that will decide whether she or he receives tenure. But young US researchers have more independence than their Japanese counterparts, who are usually constrained to follow the research leads of the laboratory head for a longer time. Consequently, young Japanese researchers probably are less likely to pursue unorthodox research directions.

## Government Funding and Peer Review

The Government has placed priority on increasing research funding opportunities for young researchers. But having to rely on the professor for laboratory space, key equipment, supplemental funding, and support staff, means that even recipients of such awards still must coordinate their research with the kouza head.

Some major funding programs involve the distribution of large funds to a senior principal investigator who then distributes the funds to other collaborating kouza heads in other departments or universities.[98] More generally, over one-third of competitive funds available for universities come from programs that tend to fund large projects involving multiple laboratories,[99] a higher proportion than in the case of the US National Institutes of Health (NIH) and National Science Foundation (NSF), the two US agencies that fund the most US university research.[100] The kouza (laboratory) head is usually responsible for cooperation with companies and other university laboratories. Thus, young researchers who want to participate in these multi-laboratory projects must do so as part of the larger kouza.

Many of the government funding programs appear to have an applied emphasis.[101] Some, such as JST's CREST, ERATO, and PRESTO, seek to bring scientific talent to bear on issues that well-known, senior scientists have identified as deserving further study, and the research focus sometimes is dominated by the views of those scientists.[102] In the case of programs such as those funded by METI's New Energy Development Organization (NEDO), the aim is more explicitly to achieve advances with direct applications for industry. As described in Chapter 7, projects in the most cutting-edge fields that involve universities also tend to involve large companies, largely foreclosing opportunities for startups to develop the discoveries from these projects. Whether government projects with an applied emphasis and industry participation produce good science, or even result in substantial benefits for the large company participants, is an unresolved question.[103]

Of all the funding programs, MEXT's Grants-in-aid for Basic Research and Grants-in-aid to Support Young Researchers are the most oriented toward supporting large numbers of individual basic research projects. Together they account for about 37 percent of total competitive research funding for universities, larger than any other program.[104] However, the peer review process that these programs share is not optimal for detecting and supporting novel but well-conceived research proposals. Although review committees usually consist of at least ten academic experts, only three or six members review an application. Because some fields are broad, reviewers must often review proposals in areas where they have no expertise. Reviews occur just once a year and each reviewer may have to review over 150 applications in a limited time period. All their scores are submitted electronically. There are no discussions, no need for the reviewers to explain in detail their ratings unless they rate a particular application extremely high or low, and no feedback to the applicant beyond the overall score, in contrast to the peer review systems of NSF and especially NIH.[105]

Japan has made considerable progress in improving the quality, representativeness, and transparency of the peer review process.[106] Whether the additional benefits of an NIH-type system are justified by the large requirement of reviewers' time and administrative resources is an unanswered question. Nevertheless, in order to encourage applications from lesser known and younger researchers to explore the frontiers of science and to be able to evaluate such applications effectively, a peer review system that brings together a large number of experts and encourages them to debate the merits of competing applications may be preferable to any current Japanese system. It would help to counter the combined influences of senior professors, collaborating companies, and (in many cases) the funding agencies themselves, that tend to channel the energy and creativity of young researchers toward subjects that are not new. It is a necessary part of any successful effort to encourage capable young researchers to establish early in their careers an independent research base.

In addition, discoveries in new niche areas probably are more amenable to development by startups and less likely to be preempted by large companies, if made by independent younger researchers.[107]

## Academic Recruitment and Promotion

Academic careers still depend more on patronage than a record of individual achievement.[108] Well into the 1990s, it was common for vacancies to be filled from within the kouza. The kouza represented a narrow career ladder where vacancies were usually filled by the person next below in the hierarchy, and the professor essentially picked his second generation successor when he selected a new joshu. Now internal promotions to the assistant professor level are discouraged, and joshus usually find their first assistant professorship in a different kouza, sometimes in a different university. However, appointment of joshus is still, for practical purposes, entirely a matter for kouza heads to decide. Selection of lead candidates for vacancies at the assistant and full professor levels depends on small internal committees in which a single professor often has a dominant voice. The committees' selection of a lead candidate is rarely questioned by the larger departmental faculty and university. Open debate is rare and solicitation of outside opinions even more so.

Open recruitment, in the sense of widely soliciting applications to fill vacancies and a commitment to select among applicants on the basis of merit, is still rare.[109] Rarer still is soliciting in-depth, objective evaluations of candidates' achievements from *outside* experts and giving considerable weight to these outside evaluations.[110]

The kouza system is becoming more flexible. In a few departments, formal kouza affiliations have been abandoned and professors make real collective recruitment decisions based on individual merit and the needs of the department, not on applicants' past affiliations with members of the department or the closeness of their research interests to those of particular senior professors. Even in such departments, however, there is usually no objective outside input into the process.

## Unequal Funding

Exacerbating the importance of patronage for academic careers is the attraction of the Tokyo and Kansai metropolitan areas and the overwhelming prestige and access to funding enjoyed by a few elite universities. It is trite

**Table 3.1.** Leading recipients of Monbusho/MEXT grants-in-aid (all types, new and continuing projects)

| Rank | 1995 | | | 2005 | | |
|---|---|---|---|---|---|---|
| | University | Amount ($10^8$ yen) | % of total | University | Amount ($10^8$ yen) | % of total |
| 1 | U of Tokyo | 125.5 | 13.6 | U of Tokyo | 201.2 | 11.7 |
| 2 | Kyoto U | 72.7 | 7.9 | Kyoto U | 131.1 | 7.6 |
| 3 | Osaka U | 61.3 | 6.6 | Tohoku U | 94.8 | 5.5 |
| 4 | Tohoku U | 41.6 | 4.5 | Osaka U | 89.8 | 5.2 |
| 5 | Nagoya U | 34.9 | 3.8 | Nagoya U | 64.6 | 3.8 |
| 6 | Kyushu U | 30.0 | 3.3 | Kyushu U | 56.8 | 3.3 |
| 7 | Tokyo Inst. Tech | 30.0 | 3.2 | Hokkaido U | 56.1 | 3.3 |
| 8 | Hokkaido U | 28.5 | 3.1 | Tokyo Inst. Tech | 45.4 | 2.7 |
| 9 | U of Tsukuba | 22.2 | 2.4 | U of Tsukuba | 30.2 | 1.8 |
| 10 | Hiroshima U | 13.2 | 1.4 | Riken | 26.3 | 1.5 |
| 11 | Okayama U | 9.5 | 1.0 | Keio U | 24.9 | 1.5 |
| 12 | Keio U | 9.1 | 0.9 | Kobe U | 24.7 | 1.4 |
| Total | | 924.0 | 100.0 | | 1714.4 | 100.0 |

*Sources*: **1995 data**: For individual universities: Matsuo 1997. For total: www.jsps.go.jp
**2005 data:** www.jsps.go.jp

but nevertheless true that most academically inclined high school students (or at least their parents) dream of entering the University of Tokyo or Kyoto University, and most academics dream of ending their careers there. As for funding, Tables 3.1–3.3 show only minor variations in the rankings of the top recipients of the three largest categories of competitive funding[111]: MEXT grants-in-aid, commissioned research,[112] and Centers of Excellence (COE) awards. Also rankings vary little over time.

The COE Program was announced in 2001 with the goals of developing up to thirty world class academic centers and differentiating research-oriented from merely education-oriented universities.[113] To no surprise, the awards have been heavily weighted in favor of universities already receiving the lion's share of other funding. Awards are usually to individual departments or new university-wide programs and usually last five years. No new awards were made in 2005, but when the program is resumed (probably in 2007), its funding will be even more restricted to a small number of institutions.[114]

The same recipients of competitive research funding are also favored recipients of operational and administrative subsidies from MEXT (Table 3.4). These are the source of salaries for full-time faculty and other general expenses in national universities, and they account for just under half of all financing attributable to research in Japanese universities.[115] These subsidies are

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**Table 3.2.** Leading academic recipients of commissioned research in 2004

| Rank | Institution | Amount ($10^8$ yen) | % of total |
|---|---|---|---|
| 1 | U of Tokyo | 177.6 | 17.5 |
| 2 | Kyoto U | 81.4 | 8.0 |
| 3 | Osaka U | 77.4 | 7.7 |
| 4 | Waseda U | 44.1 | 4.4 |
| 5 | Tohoku U | 42.2 | 4.2 |
| 6 | Kyushu U | 38.9 | 3.8 |
| 7 | Keio U | 38.2 | 3.8 |
| 8 | Hokkaido U | 34.9 | 3.4 |
| 9 | Tokyo Inst Tech | 29.9 | 3.0 |
| 10 | Nagoya U | 21.1 | 2.1 |
| 11 | Natl Insts of Natural Sci | 19.1 | 1.9 |
| 12 | Tsukuba U | 13.0 | 1.3 |
| Total | | 1012.3 | 100.0 |

*Source*: MEXT (2005).

gradually being reduced, but COE funding is expected to make up for some of the reductions in elite universities.

In contrast, 199 US universities are classified as research universities, and of these 96 are classified as highly research intensive.[116] Funding is distributed more evenly among these than among Japanese universities.[117]

**Table 3.3.** Leading recipients of centers of excellence disbursements in 2006 (for awards announced 2002–4)

| Rank | University | $10^8$ yen | % |
|---|---|---|---|
| 1 | U of Tokyo | 44.24 | 12.7 |
| 2 | Kyoto U | 33.35 | 9.6 |
| 3 | Osaka U | 24.14 | 6.9 |
| 4 | Tohoku U | 20.06 | 5.8 |
| 5 | Keio U | 17.69 | 5.1 |
| 6 | Hokkaido U | 17.39 | 5.0 |
| 7 | Tokyo Inst. of Technology | 17.21 | 4.9 |
| 8 | Nagoya U | 17.07 | 4.9 |
| 9 | Kyushu U | 12.15 | 3.5 |
| 10 | Waseda U | 10.19 | 2.9 |
| 11 | Kobe U | 8.51 | 2.4 |
| 12 | Tokyo Medical & Dental U | 5.02 | 1.4 |
| Total | | 307.59 | 100.0 |

*Source*: MEXT. http://www.mext.go.jp/b_menu/houdou/18/04/06041308/003.htm

**Table 3.4.** Projected leading recipients of operational and administrative subsidies for national universities, April 2004 to March 2010

| Rank | Institution | Amount over 6 yrs ($10^8$ yen) | Average per year ($10^8$ yen) | Approx. % of total |
|---|---|---|---|---|
| 1 | U of Tokyo | 5,364 | 894 | 7.3 |
| 2 | Kyoto U | 3,676 | 613 | 5.0 |
| 3 | Tohoku U | 3,122 | 520 | 4.2 |
| 4 | Osaka U | 3,008 | 501 | 4.1 |
| 5 | Kyushu U | 2,819 | 470 | 3.8 |
| 6 | Hokkaido U | 2,541 | 424 | 3.4 |
| 7 | Nagoya U | 2,066 | 344 | 2.8 |
| Approx. total | | 73,900 | 12,317 | 100.0 |

*Sources*: For seven universities: Uekusa and Takaoka (2005). For six year overall total: estimate based on overall totals for FY 2004 and 2005 at www.mext.go.jp applying the same rate of decrease over the entire period, as between FY2004 to 2005, i.e. $98 \times 10^8$ yen.

*Note*: These amounts represent *total* operational and administrative subsidies, not only those to support research.

Because of this concentration of resources and regional preferences in Japan, the system of recruitment in a few elite universities influences academic career strategies throughout the nation. The most elite universities manage to recruit creative and capable persons, because they attract interest from bright young researchers throughout the country. But because they generally maintain the traditional recruitment system, the need for patronage probably makes young researchers less likely to pursue unorthodox themes or research approaches. The price of initial failure is not simply losing an opportunity to work in a prestigious university. It may mean spending one's career in a university with scant research resources.

Moreover, I suspect that concentrating funding in a few institutions reduces different approaches to various scientific and technical problems, and the likelihood that less orthodox approaches will be recognized. This not only diminishes the number of discoveries that might be developed by startups, but it probably has a negative effect on Japanese science and industry as a whole.

## Restraints on Communication

It has been said that Japanese society is vertically organized in that the most important relationships are subordinate–superior relationships, and that the clarity, stability, and sometimes also exclusivity of these relationships is valued because they preserve cohesion within the group and self-sufficiency.[118] As a corollary, horizontal communication is encouraged only to the extent that it undermines neither group cohesiveness nor the hierarchical relationships that define and provide the basic structure of the overall group and its subgroups.

However, the hierarchical relationships are not only about command and control but also mutual obligation, including the obligation of superiors to look out for the welfare of subordinates.[119] Also within a group, a lot of time is spent on communication, which tends to create consensus and help the group function smoothly, as well as to develop an intra-group culture of mutual obligation.[120] Close communication within shop floor factory teams, as well as between research and product development/manufacturing divisions, has given Japanese manufacturers an edge over many overseas competitors in terms of product quality and innovativeness.[121] Also Japanese society has changed from the time these observations were made over a third of a century ago. For example, students no longer tend to rely on their professors to find jobs, but instead rely mainly on their own efforts. Attendance at various group events is becoming more flexible.[122]

Nevertheless, having lived in Japan for nine years, I believe that the basic assessments about the primacy of hierarchical relationships, group identity, and group cohesion are still valid. In particular, extra-group communications seem more hesitant and restrained than in the USA, Europe, or China.[123] Of course extra-group communication occurs frequently. But it occurs smoothly only once the communication has been sanctioned by higher levels in each party's group.[124] Freelancing, even for the benefit of the group, seems to be discouraged more than in most other countries, and it is definitely discouraged if it is perceived to be for personal benefit.

An anthropological analysis of social relationships and how they might affect ventures is beyond the scope of this book. However, there are unique barriers to inter-group communication in Japanese society that pose problems for new companies that rely on rapid exchange of information and rapid decision-making to grow—communication not only between the new companies and potential collaborators and customers, but also communication within potential collaborators regarding how to cooperate with the new company.[125]

The emphasis on group cohesion, stability, and self-reliance also manifests itself in the tendency for established companies to innovate autarkicly.

# APPENDIX

**Table 3A.** Major competitive Japanese government S&T funding programs in 2002 (includes funding to private companies and GRIs as well as universities. Programs with annual budgets under 1 billion yen (~10 M US$) not listed)

| Program name‡ | 2002 budget ($10^8$ yen) | No. new projects in 2001** | Per project annual range funding ($10^8$ yen) and duration |
|---|---|---|---|
| **Ministry of Public Management (includes former Ministry of Posts and Telecommunications)** | | | |
| Strategic Communications R&D*Δ | 14 | ? (mostly large electronics cos.) | 0.1–0.5, 3–5 yrs |
| Japan Key Technology Center (Jtech): Promotion of corporate research in basic technologies*Δ | 107 | 11 | unlimited |
| **MEXT** | | | |
| University, industry, and government cooperation for innovative enterprise creation*Δ | 71 | 28 | 0.1–0.5, 3–5 yrs |
| Grants-in-Aid | 1,703 | 21,000 | |
| JSPS: Basic research | 812 | 9,466 | <1.0, 1–5 yrs |
| JSPS: Exploratory research | 40 | 1,074 | <0.05, 1–3 yrs |
| Support for young researchers (<37 y/o) | 134 | 4,170 | <0.3, 2–3 yrs |
| Specially promoted research | 127 | 13 | <5.0, 3–5 yrs |
| Priority area research | 386 | 3,394 | 0.2–6.0, 3–6 yrs |
| Disseminating research results | 34 | 780 | Varies, 1–5 yrs |
| Special coordination funds | 177 | ~150 | |
| Ind-univ-gov't results-oriented joint res.* | 28 | 35 | ~0.27, 3 yrs |
| Strategic human research resources development | 40 | 2 | <10.0, 5 yrs |
| Research support for researchers <35 yrs old | 15 | 66 | 0.05–0.15, ≤5 yrs |
| Pioneering research in new fieldsΔ | 66 | 24 | 0.5–2.0, 5 yrs |
| Training for emerging fields | 19 | 7 | <2.0, 5 yrs |
| JST Strategically Promoted Creative (Basic) Research Programs | 427 | ~370** | |
| CREST†Δ | 289 | 173** | avg. 0.83, ≤5 yrs |
| PRESTO†Δ | 64 | 184** | avg. 0.17, 1–5 yrs |

| | | | |
|---|---|---|---|
| ERATO†Δ | 62 | 4** | avg. 3.2, 5 yrs |
| International Cooperative Research | 16 | 2** | ?, 5 yrs |
| Centers of Excellence (2004 data)†† | 308 | 113** | 0.10–5.0, 5 yrs |
| JSPS Research for the Future | 90 | Last project started in 1999. | ?, 5 yrs |
| Total MEXT | 2,776 | | |
| **MHLW** | | | |
| Grants in Aid for Health ResearchΔ | 393 | 1,251 | 0.01–10.0, 1–3 yrs |
| Basic Research in Health and Medicine | 98 | 10 | 0.5–1.0, ≤5 yrs |
| **METI** | | | |
| NEDO: Industrial Technology Research* | 53 | 93 | 0.30-0.40, 2-3 yrs |
| **MAFF** | | | |
| Research to Apply Advanced Agricultural Technologies*Δ | 18 | ? | 0.1–1.0, ≤3 yrs |
| Basic Research to Create New TechnologiesΔ | 42 | 13 | ≤1.0, ≤5 yrs |
| New Enterprise Creation R&D*Δ | 17 | 6 | ≤0.6, ≤5 yrs |
| **Environment Agency** | | | |
| General Environmental ResearchΔ | 29 | 13 (+7 smaller for young) | 0.02–1.0, ≤3 yrs |
| Grants in aid for Research into Fields such as Environmental Disruptors of Biological PathwaysΔ | 10 | 30 | 0.01–1.0, ≤3 yrs |
| **Total for all Agencies and Programs (including those not listed)** | 3,593 | | |

*Source*: Prime Minister's Cabinet Office, www8.cao.go.jp/cstp/project/compe/haihu02/siryo1.pdf

‡ Preceded by name of semi-independent funding corporation, if applicable.

* Program generally has applied research focus or aims to develop competence in particular technical areas.

** Numbers of projects for JST programs are for 2002. The same is true for the COE program, which was launched in 2002 with 113 projects. 2003 saw the initiation of an additional 133 COE projects.

Δ Program open to applicants or co-applicants from private industry.

† Program described in Kneller (2006*b*). Budget data from www.jst.go.jp

†† COE data are for the beginning of 2004 (source www.mext.go.jp/a_menu/koutou/coe/). COE is not officially classified as 'competitive research support' but because of its importance as a major new source of S&T research support I have included it in this table. The total COE funding allocation for 2004 is 30.8 billion yen.

## NOTES

1. In practical terms, this usually means the startup either receives licenses from the university covering its core technology, or is founded by faculty members or students and whose core technology is closely related to the founders' academic work.
2. Details about this analysis are in Chapter 7. About 10% of the university discovered drugs were licensed directly to large pharmaceutical companies. The remainder are licensed to biotechs.
3. See the analysis of the origins of the 170 new drugs approved by the US FDA from 1998 to 2003 in Chapter 7.
4. Branstetter and Ogura (2005). This analysis was carried out using citations to papers from major California universities only, so strictly speaking, the findings apply only to California universities. The trend toward increasing citations of academic publications resembles a step function in the case of IT, with a sharp increase in the late 1980s.
5. See discussion in Chapter 7. It would be interesting to know whether new or old companies tend to cite university publications more, and also the frequency with which patents issued to universities (as opposed to companies) become highly cited patents and/or are licensed to successful startups. Branstetter's and Ogura's analysis showed that IT patents issued to universities tend to cite academic publication much more frequently than patents issued to firms. This is not surprising, academic inventors would be expected to cite academic literature. But if the university IT patents tend to be licensed to startups, which then go on to attract funding and to have sales, this would suggest that, in IT, startups are one of the main vehicles for developing inventions that incorporate a great deal of new scientific knowledge.
6. See, e.g. McKelvey (1996), Murray (2004), Powell, Korput and Smith-Doerr (1996), and Zucker and Darby (1996).
7. Dibner (1988: 90).
8. In Chapter 4, I compare numbers in Japanese biotechnology companies with a confirmed therapeutic focus with those of US therapeutic biotechs of equivalent age, and in the process, I obtained information on the percentage of Japanese companies based on university discoveries. Dibner's data (see text accompanying previous note) covers all US biotechnology companies (therapeutic and non) and focuses on the background of the founders. Thus the two proportions are not exactly comparable, and only suggestive that Japanese biotechs rely more than US counterparts on university R&D.
9. See discussion in Chapter 7.
10. Public Law 96-517, codified as 35 USC sections 200-212. Implementing regulations issued in 1987 are at 37 CFR, §401.
11. NSB (2006: A5-3).

12. This authority was granted in a statement of Government Patent Policy, issued by President Nixon, and published at 36 Federal Register 16,886 (1971). NASA already had statutory authority to do so. Even without explicit legal authority, the DHEW had assumed the right to issue exclusive licenses in 1969. See Bayh-Dole25 (2006). Prior to Bayh-Dole, invention management practices differed among agencies. In the case of university inventions, probably the dominant policy logic was that they should be dedicated to public, in other words, either not patented or, if patented, then the patents would not be enforced or else licensed nonexclusively. However, in the 1970s, there were calls for flexibility on the issue of licensing, particularly in response to concerns about the need for exclusivity in the case of some biomedical inventions. (See the accounts of the history of Bayh-Dole in Eisenberg 1996, and Bayh-Dole25, 2006.)
13. Latker (1977) states that between 1969 and May 1977, DHEW issued 19 exclusive licenses and 90 nonexclusive licenses covering IP in its portfolio of approximately 400 patents and patent applications. Most of these dealt with inventions from laboratories under DHEW, such as the NIH *intramural* laboratories. Only a minority covered *university* inventions funded by NIH, or other agencies within DHEW.

    As the Patent Counsel for DHEW in the 1970s, Mr Latker was responsible for managing DHEW inventions in the 1970s. He was one of the main proponents for authority to license government-funded university inventions exclusively, and for delegating licensing authority to universities.
14. Up to three years from the date of first commercial sale or eight years from the date of agreement, whichever came first. (Personal communication, May 2006, from Howard Bremer, Emeritus Patent Counsel, Wisconsin Alumni Research Foundation.)
15. In 1974 (the latest year for which Latker, 1977, provides data) universities were managing 329 DHEW funded inventions under IPAs and had issued 78 exclusive and 44 nonexclusive licenses. These numbers were trending up.
16. Latker (1977), Eisenberg (1996), and Bayh-Dole25 (2006). Most of the pressure to facilitate exclusive licenses came from established pharmaceutical companies rather than biotechs, of which there were few before 1980 (communication from Mr Bremer, see note 14 above).
17. See, e.g. the statement of W. Novis Smith, Director of Research and Development, Thiokol Corp. in The Role of the Federal Laboratories in Domestic Technology Transfer: Hearings Before the Subcommitte on Science, Research and Technology of the US House of Representatives Committee on Science and Technology, 96th Congress (1979), at n. 125, pp. 621–22; referenced in Eisenberg (1996: 1699).
18. Regarding the former reason, see Shane (2004, especially: 69–7, 173, 232, and 260–1). Regarding the latter reason, see Barnett (2003).
19. High Voltage, Inc. was established in 1946 with the financial support of the venture capital firm American Research and Development to commercialize

Van de Graaff generators, Van de Graaff having conceived of these generators while a student at Oxford, then Princeton, and later a researcher at MIT. MIT managed the patents and, after considerable discussion about the propriety of exclusive licenses to academic inventions, decided that exclusive licenses to High Voltage were justified in light of 'the essential business requirements for bringing an invention into use by the public'. Of special note, some of the exclusively licensed inventions were funded by government contracts. (Eisenberg (1996) notes that the Defense Department which funded the MIT research, usually let contractors retain rights to inventions it funded.) Also, MIT had earlier licensed Van de Graaff's inventions to either General Electric or Westinghouse, but these companies had failed to develop the technology. By 1955, High Voltage was a 'reasonably successful company'. (Account and quotations from Etzkowitz 2002.)

20. Cetus Corp., founded in 1971 by Nobel Physics Laureate Donald Glaser of the University of California at Berkeley and two nonacademic colleagues, may be able to claim the distinction of being the first university biostartup that achieved a notable degree of success, developing genetically engineered interleukin-2 and beta interferon and, most notably the polymerase chain reaction (PCR) method for gene duplication and amplification. But although Cetus recruited university scientists, I do not know the degree to which it relied on licenses from universities or close links with university researchers to make its key discoveries (see Rabinow 1996).
21. McKelvey (1996: 103, 151). These licenses were from UCSF, the employer of Genentech's cofounder Herbert Boyer. UCSF agreed to license Boyer's inventions to his new company only after internal debate. Genentech also received nonexclusive licenses to other university inventions, such as the basic recombinant genetic engineering invention by Boyer and Stanley Cohen of Stanford.
22. According to Dibner (1988: 101) about 79 biotechnology companies (not only university startups) were formed in 1981 compared with about 17 in 1979. Dibner uses a broad definition of biotechnology company (companies working with new technologies of genetic engineering, monoclonal antibodies, large-scale cell culture, etc.) that includes some large pharmaceutical companies, subsidiaries of large companies and companies whose main business is in other fields. Among the notable biostartups founded between 1976 and 1980 were Biogen (1979 by researchers from Harvard, MIT, and the University of Zurich) and Molecular Genetics by researchers from the University of Minnesota. 1981 saw the founding of Chiron (Harvard), California Biotech (UCSF), and others.
23. Unless otherwise noted, support for the statements in this section are in Kneller (2003*a*) which describes the institutional and legal evolution of Japan's technology transfer system until 2003. This article is based on statistical analyses described in the article, documents cited in the article, and conversations

with a wide range of university researchers and administrators and government officials.

24. *National universities* account for Japan's leading centers of university R&D. Please refer to the Glossary at the end of this book for a further explanation.
25. I.e. Commissioned and Joint Research regardless of whether the sponsor is a private or government organization. See Glossary.
26. Known formerly as *kouhi* and more recently as *unei koufukin* funding, base amounts are usually less than US$ 10,000, and the majority is pre-allocated to utilities and other infrastructure expenditures.
27. In 1998, standard research allowances accounted for 46% of national university R&D expenses, but as noted in the previous note, most of these funds were earmarked for infrastructure costs. Donations accounted for 13% of the R&D budget, 25% of the budget net of the standard research allowances. Therefore, somewhere between 25% and 59% of R&D funds were attributable to non-project specific funding (Kneller 2003*a*).
28. Kneller (2003*a*) provides evidence for these estimates.
29. In the case of inventions arising under formal sponsored research agreements with companies, the companies could usually arrange to co-own the inventions with the government. Under article 73 of Japan's patent law, either co-owner can freely use such an invention. But it cannot license its rights, even nonexclusively. Usually this was not a disadvantage for large companies, (in fact co-ownership gave them a de facto royalty-free exclusive license) but it was for ventures, because ventures often need to transfer their IP in the course of business alliances.
30. Thirty-nine Japan Bioindustry Association respondents (almost all large or established companies) to a 1997 questionnaire, indicated that each had an average of 156 university relationships, the vast majority based on donations to individual professors. The average expenditure per relationship was less than US$ 10,000 (JBA 1998).
31. MEXT (2005).
32. See Hashimoto (1999) and Odagiri (1999) who describe the close prewar university industry linkages and how those linkages went underground (became informal) in the postwar decades. See Kneller (2003*a*) for descriptions of the ban on paid consultation, as well as restrictions related to sponsored research agreements, licensing, and using sponsored research funds to pay personnel expenses.
33. Many universities would accept at face value an inventor's assertion that an invention arose under donation funding and would not even require such inventions to be reported. A few universities did require all inventions to be reported, but these too did not question assertions that the inventions arose under donations or standard research allowances. All national universities had invention committees composed of faculty members (i.e. colleagues of the inventors) responsible for deciding the attribution of inventions, but these

usually met infrequently and to my knowledge never questioned the inventors' assertions. They acted as rubber stamps, and university administrative offices were aware of this.

34. See note 29.
35. *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*a*). 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 US (National Science Board, Science and Engineering Indicators, 2004).
36. Baba, Yasunori, Shichijo and Nagahara (2004).
37. See Kneller (2003*a*). The terms under which the startup had to license back, from the pharmaceutical companies, the founder's own inventions while not excessive, were not trivial.
38. Monbusho (1998) and n. 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 one 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).
39. Frequent reasons for companies not developing university inventions included their perceptions that the market was too small, and their 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 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). Reference to the success of well-known US TLOs, such as those of MIT and Stanford, was frequent (Monbusho 1998). In other words, the advisory committees reasoned that universities could make better decisions than individual inventors about which companies should receive exclusive rights to university discoveries and could better insist on contractual provisions (royalties, due diligence clauses, etc.) that would increase incentives for the licensees to develop the inventions and for inventors to continue to cooperate with development.

40. However, there are some examples of small companies benefiting from consultations with professors in well-known universities (Chapter 4 and Kneller 2003*b*).
41. At least this is the impression from key advisory reports, such as Monbusho (1998), advocating the reforms.
42. [Daigaku nado gijutsu iten sokushin hou] (Law No. 52 of 1998).
43. *TLO* stands for technology licensing office or technology licensing organization. This is the general term used in Japan to refer to a university licensing, technology transfer, or technology management organization. It also has the same generic meaning in the US.
44. However, these cannot be used to pay salaries of permanent TLO staff nor the fees of outside patent attorneys. Many US TLOs rely on subsidies from their universities, yet over time more are becoming self-sufficient (based on conversations with US TLO officials). Also despite operating deficits, it seems that many US universities have decided that the long-term benefits (technology development, new company and job creation, and increased industry sponsorship of research) outweigh the shortfalls in license revenues. Whether the same reasons justify subsidies in the Japanese case remains to be seen. Another potential problem is that the METI/MEXT subsidies are distributed as equal size block grants, whereas in the US, decisions are made by the university administrations. Thus the US system may facilitate better alignment of technology management with individual university goals.
45. [Sangyou katsuryoku saisei tokubetsu sochi hou] (Law No. 31 of 1999).
46. 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 make 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 2003*a*). 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.
47. [Sangyou gijutsu ryoko kyouka hou] (Law No. 44 of 2000).
48. Exceptions are permitted to enable faculty with special expertise to serve as directors of TLOs and accounting firms, even though such activities are not directed toward commercializing the faculty member's discoveries. The names of nearly 3,000 faculty that had obtained permission to serve as managers or directors by the end of 2003 are available at http://www.mext.go.jp/a_menu/shinkou/sangaku/03121501.htm
49. Prior to this law, funds for commissioned and joint research could only be disbursed once a year on a fiscal year basis. Disbursements had to be approved by MEXT and the Ministry of Finance and thus funds were not available

between February and July. In other words, funds could only be used for equipment purchases and some travel, not for personnel.

50. [Kokuritsu daigaku houjin hou] (Law No. 112 of 2003).
51. MEXT (2002).
52. In 2003, 5 years after enactment of the TLO Law, the 35 approved Japanese TLOs applied for 1,679 Japanese patents (average 48 per TLO). In comparison, 109 US TLOs applied for 1,584 US patents (average 15 per TLO) in 1991, 11 years after enactment of the Bayh-Dole amendments (data from METI and AUTM).
53. In 2004, 38 Japanese TLOs issued 626 licenses, approximately 16 per TLO (METI). In 1991, 109 US universities issued 1,229 licenses, average 11 (AUTM).
54. Average royalties per royalty-earning license was on the order of US$ 17,000 in 2003, and this has probably not increased substantially. In comparison, in 1991 US TLOs received US$ 218.4 million in royalties on 2,602 royalty earning licenses—about US$ 84,000 per license. In 2004, this had increased to approximately US$ 121,000 per license. The difference may be due both to the US averages being inflated by a small number of 'blockbuster inventions (of which Japanese universities so far have none), to Japanese TLOs being hesitant to bargain hard with large companies for high royalties, and to some of the best inventions having been siphoned off under joint research agreements. See Kneller (2006).
55. Using the same definition for a *core* university venture (i.e., a new company based directly on university discoveries), the latest METI survey report says the overall total in Figure 3.1 (1,503 ventures) should be discounted by 44% to obtain the number of core ventures. In other words, according to METI there were 845 *core* university startups in mid–late 2005. METI kindly provided me lists of startups attributed to U Tokyo and Keio Universities in the 2003 METI survey, and I found out information about most of the companies on these lists (see Chapter 4). My independent analysis of these startups (See Chapter 4, Appendix 2) suggested a somewhat lower discount factor, leading me to conclude that the most appropriate discount factor is about 40%.
56. See Chapter 4.
57. 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 nonacademics. 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.
58. Then within five years, 10 million yen must be deposited as paid in capital in the case of joint stock companies, 3 million yen in the case of limited liability companies.

59. The average amount of annual funding per joint research project in 2004 was around US$ 20,000, nearly identical to the average in 2000 (MEXT 2005).
60. *Large* companies are defined as having over 300 employees, *small* as having 21 to 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, Hosono, Fukugawa and Kondo (2005). The 2003–4 data are from MEXT (2005) which does not give a breakdown by company size.
61. In contrast, a joint owner of a US patent can transfer rights his or her rights to a third party without the consent of the other joint owners, barring a contractual agreement to the contrary among the joint owners.
62. 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.
63. On a few occasions, companies that are coinventors on inventions insist that no patent application be filed, essentially converting the invention into a trade secret.
64. In cases of an invention that overlapped two of these categories, I assigned it one-half to each field—on rare cases, one-third to each of three fields covered by a single invention. The full analysis and results are described in Kneller (2006).
65. Activity-specific funding means funding other than the *operational and administrative subsidies*. These subsidies pay for full-time salaries and infrastructure, but leave little to support specific projects (i.e. equipment, stipends, travel, and so on). Activity-specific funding includes (in order of largest to smallest) MEXT grants-in-aid, Commissioned Research (mainly from government agencies), donations, and finally Joint Research.
66. Unlike many US universities, most Japanese universities permit joint and commissioned research between a startup and the founder's laboratory.
67. Applications are usually filed jointly by the company and university, with the company paying a majority of associated costs.
68. *International Herald Tribune-Asahi Shimbun* (2004). 'Seeking profit, firms leave basic R&D to universities', Jan. 15, 21.
69. Nationwide, the numbers of company researchers engaged in joint research in universities doubled from 1,398 in 1992 to 2,821 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*.
70. See Chapter 7.

71. Personal communications with US technology transfer officials in 2004 and 2005.
72. However, any comparison along these lines ought also to take into account consulting and startup formation.
73. Chabrow (2005).
74. These agreements usually pertain to open source software applications (Kauffman Foundation 2005; IBM 2006).
75. 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.
76. Chapter 7 discusses possible reasons why preemption is less common in biomedicine.
77. More on this issue in Chapter 7.
78. As indicated in Figures 3.4 and 3.5, startups and other ventures also engage in joint research with universities, although on a smaller scale than large companies and disproportionately in biomedicine. However, startups sponsoring research in the founders' laboratories raise conflicts of interest issues that have not yet been resolved or even openly debated in Japan. For example, once a laboratory director has formed a company, is it appropriate that joint research agreements with the company enable most of the laboratory's discoveries to flow to that company, a process known as *pipelining* that is discouraged in the USA (Shane 2004)? What about the risk that the laboratory will be turned into the professor's company's laboratory, leveraging public research support and appropriating not only IP but also the energy and creativity of graduate students? To a degree, these risks exist in any collaborative research situation, but they are heightened when the collaborating company is also the professor's startup. US universities generally discourage such sponsored research, but many also deal with these issues with some degree of flexibility.
79. 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 in Germany, as it does in Japan.
80. The following summary of the situation at MIT is from Etzkowitz (2002).
81. These policies gave faculty the leeway they wanted in the case of consulting, but in the case of IP they gave MIT authority to own work related inventions, more than seventy years before the Japanese government (acting without strong backing from universities or their professors) would order often unprepared Japanese universities to claim such inventions.
82. Based on 2006 discussions with MIT researchers.
83. As of 2006, there seemed to be little effort by universities to assert control over their discoveries and over faculty relations with large companies in ways that might conflict with the interests of the companies. Their stance was accommodating rather than assertive. The main areas of disagreement concerned how much companies should pay in overhead (30% still being the ceiling, with

most payments retained at the department level) and whether companies that want exclusive rights to joint research inventions should pay, in addition to the exclusive license fee, for the universities to give up their right to practice jointly owned in inventions under article 73 of Japan's Patent Law. In case of disputes, inventors often side with companies.

84. In 1994, national universities received about $230 \times 10^8$ yen in commissioned research, in 2004, $772 \times 10^8$ yen, a more than threefold increase. The vast majority of commissioned research was from government-affiliated agencies, such as JST and NEDO (METI 2005 for 1994 data, MEXT 2005 for 2004 data) $10^8$ yen $\cong$ \$1 million.
85. Some might question this initial premise, citing the large number of startups being created each year as shown in Figure 3.1. My continued doubts about the depth of entrepreneurship in Japanese universities relate to issues addressed later in this book and to the aforementioned weakness of startups (with some exceptions, mainly in biomedicine). It is also based on discussions with students and faculty, and personal knowledge of quite a few startups. Some faculty members are interested in founding companies, but many of these are also engaged in joint research projects with large companies. The interests of the large companies usually win out, although I know of one possible exception that I describe in Chapter 7. If a startup is formed, its business scope is confined and/or it becomes a de facto subsidiary of one of the large joint research partners. As for students, most masters students want to work in large companies. While Ph.D. students may have more varied career goals, very few MS or Ph.D. candidates want to work in ventures—either ventures with high risk/return prospects or ventures with low risk/return prospects. I administer a survey to about half of the new graduate students in my research center each year, and consistently fewer than 10% say they would consider work in ventures to be desirable. Attitudes in less prestigious universities may be different.
86. For example, compromising core of academic values, scientific integrity, or the quality of graduate students' education, or harm to patients in clinical trials if precautions are sidestepped to enhance business prospects for a company whose therapy or device is being tested (see note 88).
87. See for example, the regulations for the University of Tokyo in Japanese at http://www.u-tokyo.ac.jp/per01/d04_10_j.html. These require reporting of consultancies, management positions, contractual relationships, and stock holdings in companies with which one has cooperative research, advisory or business relationships; as well as income from intellectual property and instances in which students have been sent to companies under cooperative relationships.
88. In 1999, a young man died in the course of gene therapy trials in the University of Pennsylvania. The subsequent investigation uncovered various shortcomings in trial procedures that contributed to his death. The principal investigator (PI) had founded a startup to commercialize the gene therapy technology

that was the subject of the trial. Although a link between the death and the PI's financial interest in the outcome of the trial was not clear, this focused attention on the need to prevent, or manage carefully, such conflicts of interest in the case of clinical trials (Weiss, Rick and Nelson, Deborah (2000). FDA halts experiments on genes at university; probe of teen's death uncovers deficiencies (*Washington Post* January 22, 1)).

89. Tokushima University (2006). The reporting requirements go a bit beyond those of the University of Tokyo regulations (note 87) in that they require reporting of donations and sponsored research. Perhaps more importantly, they recommend coordination with the institutional review boards (IRBs) that are responsible for reviewing research proposals involving human subjects to try to ensure the safety, privacy, and voluntary, informed participation of the human participants.
90. The effort was sparked in part by incidents abroad such as that mentioned in note 88 and also by 2003 revelations in a nationwide daily newspaper that researchers in a major Japanese university hospital involved in human testing of a new therapy owned by a startup of that university had received stock in the startup, which they sold just before the startups IPO. As an illustration of the widely held critical stance toward faculty entrepreneurship, the newspaper revelations focused criticism on the fact that the researchers had made a profit. However, the university was aware of the stock holdings and the researchers sold their stock at the advice of the IPO underwriters in order to avoid the appearance of impropriety. (They could have sold their stock for more if they waited until after the IPO.) Absent from the initial media reports were concerns about the possibility that the researchers' financial interest in the outcome of the trials might have led them to take shortcuts in the planning or execution of the trial that might have compromised patient safety.
91. See, for example, the reporting requirements and decision process at the faculties of medicine of Tohoku University at www.med.tohoku.ac.jp/jimu/rinri/3.rinsyo.pdf and the University of Tokyo at http://www.crc.h.u-tokyo.ac.jp/doctors/documents/riekisouhanshinkokusho_000.doc. These both require reporting of any interest above 1 million yen (about $8500), and sharing of information with IRBs (see note 89).
92. Conflict of interest issues are far from resolved and management procedures are far from uniform in the USA. But there is more open debate at an institutional level, with deans of various medical schools actively involved in working out ways to manage a variety of often complex situations. See Kaiser (2002) discussing recommendations by the Association of American Medical Colleges. Also many US universities openly describe how specific conflict of interest issues will be managed.
93. Out of 40,804 students who graduated with masters degrees in natural science, engineering, agriculture, and pharmacology in 2004, immediately after graduation at least 78% of these (31,882) joined the labor force, and 13% (5,212) continued academic studies (mostly in doctoral programs). Information is not

available on the remaining 9% (MEXT Basic School Survey 2004). (To my understanding, most persons who study for doctoral degrees in Japan, first obtain a masters degree).

US data show only that 61,639 students graduated from US universities with masters degrees in these same fields in 2002, while 19,640 graduate with doctoral degrees in 2003 (NSB 2006: A2-63, 75). Even if none of the Ph.D. graduates received masters degrees (an unlikely assumption, although it is more common for Ph.D. candidates to skip a masters degree in the USA than Japan), and thus the total number of first or second year US S&E graduate students is around 81,279 (61,639 + 19,640), the percentage of first year S&E graduate students pursuing doctoral degrees would be around 24%, higher than the estimate of 13% for Japan. If half of US doctoral recipients obtain a prior masters degree, then approximately 27% of first or second year S&E graduate students in US universities are planning to pursue doctoral level research—double the estimated percentage for Japan.

94. Between 1990 and 2004, the number of S&E doctoral graduates from Japanese universities (excluding social science) increased over threefold from 4,525 to 10,770 (MEXT Basic School Survey, various years). However, 4,077 (38%) of the latter figure were doctoral degrees in either medicine or dentistry, which are usually awarded to persons in their late 40s who are already junior faculty in medical or dental schools. These persons do pursue research to fulfill their degree requirements, and thus might be loosely equivalent to persons pursuing the Ph.D. component of a combined MD/Ph.D. program in the USA. But they are older, on average, and their career paths are already set. (Coleman's 1999 account of academic careers describes how these extended doctoral programs as part of the indentured servitude future professors in medical and dental schools must endure.)

In comparison, the number of US non-social science S&E doctoral graduates (excluding medical doctors, MDs) in 2003, was 19,477, roughly two- or threefold the number of Japanese graduates in 2004, depending on how the Japanese doctorates of medicine and dentistry are counted. About 37% of these were awarded to foreign students as compared with about 13% of the Japanese doctoral degrees (NSB 2006: A2-122, 129).

Note, the Japanese figures in the above analysis do not include so-called *thesis doctorates* (ronbun hakasei) which are awarded on the basis of research done outside the university, typically in a corporate laboratory. These do not involve university graduate level course work. Supervision by the professor who approves the thesis is often minimal. In 2001, approximately 950 thesis doctorates were awarded in engineering compared to about 2,950 normal doctoral degrees, and in the sciences (including social science) about 200 thesis doctorates were awarded compared to about 1,350 normal doctorates (NISTEP 2004). MEXT is trying to reduce thesis doctorates and encourage all persons who want doctoral degrees to go through formal university programs.

95. There were about 5,250 Japanese postdoctoral researchers in S&E fields (excluding social science) in 2003 (MEXT Personnel Advisory Com. 2003). In contrast in 2003 there were 45,237 postdocs in S&E fields excluding social science and psychology in the US (NSB 2006: A2-103), more than an eightfold difference. Traditionally, postdoctoral positions have been considered undesirable in Japan, refuges for persons not capable enough to obtain permanent employment in universities or industry. However, as the number of Ph.D. graduates increase, the number of postdocs is likely to increase.
96. 6,305 of 19,640 doctoral degree recipients from US universities in engineering and the natural sciences in 2004 (32%) were female (NSB 2006: A2-75,77). Among 6,693 doctoral graduates in equivalent fields from Japanese national universities in 2004, 1,109 (16.6%) were female, roughly half the US percentage (MEXT 2004 Basic School Survey, p. 424–5).

    As for university faculty, among approximately 132,100 doctoral degree holding full-time faculty (instructor to full professor level) in engineering and natural science in US universities and colleges in 2003, approximately 30,700 (23%) were female (NSB 2006: A5-46–49). Among 36,772 full-time faculty (joshu to full professor) in equivalent fields in the central academic divisions of Japanese national universities in 2004 *plus all full time faculty* in special institutes affiliated with national universities and graduate-level-only national universities, 2,598 (7.1%) are female, roughly one-third the US percentage.
97. Some kouzas contained an instructor (*koushi*) intermediate in rank between a joshu and the assistant/associate professor. A koushi was expected to emphasize mainly teaching, and sometimes was not considered to be in line to fill a vacancy at the assistant/associate professor level. In 2007, titles are expected to change. Assistant professors (jo kyouju) will become associate professors (jin kyouju). Assistants (joshu) will become assistant professors (jo kyou).
98. MEXT's Priority Area Research projects (recently folded into the new Development of Innovative Seeds and the Promotion of Key Technologies Programs) and JST's CREST and ERATO projects tend to be of this type. See Appendix Table 3A.
99. The following MEXT programs tend to fund such projects: grants-in-aid for Specially Promoted Research, CREST, ERATO, Research for the Future, Centers of Excellence, Special Coordination Funds for Strategic Human Research Resources, Pioneering Research in new Fields, and Training for Emerging Fields. These accounted for 101 billion yen (36%) of MEXT's total competitive extramural research budget of 277 billion yen in 2002. As discussed in Chapter 7, university funding by METI and the Ministry of Public Management funding tends to involve multiple laboratories (consortium research) at least in cutting-edge areas of S&T. On the other hand, funding by the MHLW and MAFF is probably most often in the form of grants to individual laboratories. (See Appendix Table 3A and Kneller 2007.)

    Some of the programs mentioned above, such as Centers of Excellence and Special Coordination Funds, are non-project-specific funding to support research and education in a particular department or center. The committees that evaluate competing applications for such funding generally do not have in-depth expertise in individual areas of research and tend to make decisions based on a macro-level analysis of competing institutions (Kneller 2007*b*). The disadvantage of this evaluation system is that it tends to perpetuate concentration of resources in a few prestigious institutions (discussed further below) and it leaves authority about which individual researchers and projects to fund in the hands of individual kouza and department heads. *It provides no alternative to the traditional system of recruitment and promotion, for bright young energetic researchers who do not have patronage.*

100. In 2005, NIH accounted for about 66% of total US government support for academic R&D, and NSF accounted for 13% (NSB 2006: A5-11).

In 2002, NIH supported 34,613 *investigator-initiated basic research projects*, paying about US$ 365,000 per project, including overhead—about 75% of its extramural R&D budget. The same year NIH funded 1,261 *center projects* (e.g. comprehensive cancer centers to combine research and patient care) at a total average cost of US$ 1.74 million per center, about 13% of its R&D budget. In 2003, NSF funded 6,140 research grants, mostly for *individual* research projects in universities, at an average cost of US$ 135,000 per project. It also spent US$ 364 million to support about 300 research *centers* in US universities (e.g. collaborative engineering research centers) for about a 3 to 1 ratio of individual to center funding.

101. See the list of Competitive Research Funding Programs [Kyousou-teki kenkyuu shikkin seidou ichiran] issued by the Cabinet Office at www8.cao.jp/cstp/compefund/ichiran.html. Appendix Table 3A presents a modified version of this list. A considerable number of the non-MEXT grants-in-aid programs have an explicit applied emphasis and/or are open to applicants and coapplicants from industry. Even programs labeled as 'basic research programs' such as JST's CREST, PRESTO, and ERATO stress the need for research results to have practical applications and social contributions. (See the description of the main competitive funding programs open to university researchers in Kneller 2007.)

Perhaps the hypothesis that university research tends to be more applied in Japan than the USA should not be overstated. To put this matter in perspective, a colleague at the university of Tokyo recently remarked that when he applied for a large MEXT grant-in-aid, he had to decide whether to portray his proposal as application or basic research-oriented. He chose the latter and, somewhat to his surprise, got the grant. Also, I have reviewed lists of NSF awards in nanotechnology. Many of these seem to combine basic research and applications themes. The mission of NIH, the largest supporter of US university research, is research to improve health, so many of its projects have applications to health and medicine. NIH routinely issues requests for proposals (RFPs) that solicit applications in specific areas deemed to have high priority for science or health.

*Nevertheless*, the review in Chapter 7 of non-MEXT grants-in-aid projects indicates that in cutting-edge fields, such as nanotechnology, various fields of cellular biology, fuel cells, wireless networking, and communications, consortium research is very common. Projects in these areas frequently involve large companies and universities and usually aim for industrial applications.

102. Of course, creative applicants often can write applications that fall under the ambit of the predetermined research themes but nevertheless allow the applicants to pursue their own research ideas. However, according to Japanese colleagues who have applied to some of the programs that set forth specific research themes, sometimes the review process is dominated by a single research group that expects applicant to address lines of research that group considers to be important.

103. There are few systematic studies that look beyond metrics such as numbers of patent applications or of joint university–industry publications. As for anecdotal evidence, conversations with university and industry researchers prior to 2004 generally revealed negative perspectives, made more believable by the mention of exceptions that seem to prove the rule: e.g. amorphous silicon for solar cells and drug delivery systems. A professor in the field of IT, one of the few who in 2000 could claim significant commercial applications for his research, remarked that year that large government applied research projects are a distraction for Japan's most capable students and their professors—relatively easy money (at least for well-known professors) for projects that are not critically evaluated either before or after they take place. He said that, without such funding, researchers in IT would be forced to work more closely with companies and they would come to grips with problems that are of real importance to industry. Corporate researchers generally tended to agree, and said that they obtain greater benefit by sponsoring university research on their own.

On the other hand, perspectives of companies appear to be becoming more positive. Also, the ERATO program, in particular, has been carefully studied and the results have been praised in Japan and overseas (JTEC 1996; Hayashi 2003). Finally, I am impressed with the progress in various fields of engineering, IT, and materials science by some of the academic research teams funded by agencies such as JST and NEDO. These impressions are shared by exchange scientists (primarily from Europe) in these fields who have also attended presentations by the heads of these research teams. (These presentations are by better known researchers, and thus may not be representative of most recipients of such funds.) The research may indeed have a practical orientation, but in the process of developing practical applications, it is clear that fundamental scientific knowledge is expanding. What is less clear is the consistency with which industry is developing these discoveries. Almost all these researchers have industry collaborators (usually large companies) and in some cases it is clear that the companies have pushed forward rapidly with commercial development of the professor's research. In other cases, commercial interest (or merit) is less clear. One of the underlying questions of this book is whether a more supportive environment for startups would enable startups to develop some of these discoveries more rapidly, or whether the Japanese system of substantial funding for applied research coupled with close interactions with established companies provides a better environment for progress in basic science as well as the commercialization of university discoveries.

104. See Appendix Table 3A showing that these programs constituted 55.5% of total MEXT grants-in-aid in 2002. Kneller (2003) shows that in 1998, MEXT grants-in-aid (all types) constituted about 67.7% of total competitive funding for research in Japanese national universities.
105. NSF uses mail review by experts, follow up discussions by an assembled committee knowledgeable about the field, and written feedback to the applicants about the bases for decisions. The NIH peer review system goes even farther to ensure that projects are selected on the basis of merit and likelihood of scientific progress. This process is based on committees consisting of about twenty experts (attempting to achieve diversity in age, gender, scientific perspectives, etc.) who meet three times per year to review applications. During their committee service tenure, their universities accord them reduced teaching and administrative responsibilities. Deliberations incorporate a process of advocacy and open debate, and in the end a written rationale for the committee's decision is prepared for the applicant. According to my own experience at NIH and to observations of Japanese researchers who served on or observed NIH peer review committees, this process tends to bring out strong points and shortcomings that might not be initially apparent (Hayashi 1996; Suga 2004). In addition, each NSF and NIH committee is managed by a Program Officer (almost always a doctoral degree holder) with a strong scientific/technical background in the committee's field. This person ought to understand the frontiers of knowledge in the committee's field and where research priorities lie. She or he can give feedback to reviewers and discuss program goals with prospective applicants. Such in-house expertise and opportunities for dialogue are absent in the Japanese funding agencies with which I am familiar, at least the divisions that manage peer review and funding allocation. Nevertheless, the NIH system has been criticized for being unwieldy, time consuming, and still deficient in detecting novel research proposals. (See Kaplan 2005, although this article fails to substantiate the most serious criticisms and to show that alternative systems would likely be better.)
106. The decision process is more systematized and transparent, numbers of reviewers have been increased from 3 to 6 for many programs, names of review committee members are made public two years after their tenure ends, and applicants can receive their overall score in the event their application is denied.
107. See Chapter 7.
108. For an in-depth exposition, see Coleman (1999). See also Whitely (2003).

109. I am familiar with recruitment and promotion practices in only a few Japanese universities, but these include two of the leading national universities and one leading private university. Within each of these three universities, I know of one department that practices this form of open recruitment. But persons within these departments themselves say that they are pioneers within their universities. In other words, they are exceptions that prove the rule.
110. Such steps are under consideration in a few departments, but I know of no department that has implemented such procedures. However, such procedures are common in US universities.
111. See Appendix Table 3A for a list of all competitive funding programs and their sizes. Most of these are open to university applicants, and the MEXT programs mainly fund university research. Funding amounts are in units of $10^8$ yen, which is slightly little less than US$ 1 million (the exchange rate having varied between 105 and 125 yen per US$ since 2000). A brief explanation of the Centers of Excellence Program follows in the text. A fuller description is in Kneller (2007) and also various reports issued by the Tokyo Office of NSF.
112. Support for university research from JST's Basic Research Program (CREST, PRESTO, and ERATO), JSPS's Research for the Future and from METI/NEDO and all other ministries *other than* MEXT is generally classified as *commissioned research*. Contract research from private companies that does not involve company researchers working collaboratively in university laboratories is also classified as commissioned research. However, such funding probably accounts for less than 5% of commissioned research funds, at least in major universities. Most industry funding is either under Joint Research contracts or donations (Kneller 2003).
113. See Shinohara (2002).
114. According to discussion with university and government officials.
115. Kneller (2003, 2007).
116. See the classifications of the Carnegie Foundation for Advancement of Teaching at www.carnegiefoundation.org. These well regarded classifications are used in NSB (2006). As an indication that there are many other universities in the USA, the 199 research universities account for less than half (89,500 of 194,100) of full-time university faculty that hold S&E doctoral degrees (NSB 2006: A5-46).

    In 2004, Japan had 87 national universities, 4 national academic research institutes under MEXT (such as the National Institutes of Natural Sciences in Okazaki listed in Table 3.2), 80 local government universities, and 542 private universities.
117. NSB (2006: A5-18, 19). It might be argued that, because the Kanto (Tokyo-Yokohama), Kansai (Osaka, Kyoto & Kobe) and Nagoya regions account for a high proportion of Japan's 127 million population, it is appropriate for leading universities in those regions to receive a disproportionate share of R&D

funding. However, a separate analysis shows that these three regions together account for 43–49% of population (depending upon whether metropolitan regions (43%) or entire prefectures (49%) are used as the basis for population counts) while universities in these regions receive 63% of MEXT grants-in-aid (Kneller 2007). This indicates, at least on a nationwide level, regional funding imbalances even in proportion to population.

118. Nakane, Chie. (1970). *Japanese Society*. Berkeley: University of California Press. This is one of the classic analyses of Japanese society. Nakane notes that the superior–subordinate relationship is not so much a requirement of personal loyalty, as it is a requirement to uphold the structure and stability of the group.
119. Doi (1971) asserts that *dependence* is a mutually recognized and accepted part of these relationships that increases their stability and palatability/appeal. If this is true, then freelancing might be seen as threatening the foundation of such relationships.
120. My impression is that group membership in Japan tends to be more time intensive than in the USA. Academic study groups (kenkyuu kai) organized by individual professors are quite common and meet regularly (once a month or more, usually at night), although usually not directed at a particular project or issue. University student study groups meet regularly for long hours, often in evenings or on weekends. Elementary school volleyball entails not only students but also parents devoting most of their weekends to team activities. Weekly university labor union meetings run late into the evening, oblivious to the fact that some of the representatives at those meetings have children and who need or elderly relatives care at home.
121. See Chapter 7 and the works by Aoki and Chuma cited therein.
122. Although parents are still generally loath to request to leave evening meetings early in order to take care of family members.
123. Here are a few disparate examples: In Japanese dining halls for faculty and graduate students, members of one laboratory usually sit together and are rarely joined by outsiders. The doors to most laboratories and faculty offices are closed. Unless involved in common projects, communication among graduate students and junior faculty even in the same laboratory is not close. Groups involved in particular projects tend to stick to themselves. If a graduate student or even a junior faculty member has a research question, she or he will generally ask his or her supervisor for help. Approaching other members of the laboratory or going outside the laboratory seems relatively rare, according to overseas researchers who can compare laboratory environments in Japan with those in America, Europe, and China. Work related social functions rarely involve spouses or friends from outside the group. A few negative comments about a particular person by a senior professor will lead other academics, not only in his or her kouza, but also outside persons who in one way or another acknowledge his or her authority, also to cease

communication with that person. Managers and lead researchers in a venture company, who know a range of outside contacts who might help the venture, will not contact those persons unless they feel they have a clear go-ahead from the head of the venture. (I strongly suspect the same applies to large companies.)

Are these observations unique to my experience, or to foreigners in Japan, or to the University of Tokyo? Perhaps—but based on my observations, I think not. It would be helpful for anyone who doubts these conclusions to present evidence that shows the opposite.

124. In this regard, see Yamagishi, Cook, and Watabe (1998) and other writings by Yamagishi suggesting that general trust (the tendency to trust another person regardless of whether he or she is bound by the same stable social relations, i.e. is a member of the same family or work group) is lower in Japan than America, and this is due largely to the closed nature of key social groups in Japan, particularly work-related groups.
125. This issue is dealt with again in the following and final chapters.

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