Untangling Fact from Fiction in Innovation Policy Reform: The Public-Private Research Linkage in Japan

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Abstract

Policy reform in Japan points to the innovation system as a growth impediment, particularly the research and development linkage between Japan's university and industry sectors. This follows from perceptions of positive net returns from certain university-industry linkage policies of the American economy, and the conventional wisdom of a disconnect between Japan's university and industry sectors. This research empirically analyzes the conventional wisdom, and elucidates the need for critical assessment of American policy instruments in the context of the distinct Japanese policy framework. The analysis includes assessment of university patenting, industry-to-university R&D funding flow, and joint authorship of research articles. The conclusion is that the assumption of disconnect and the direction of policy reform the assumption supports are misconstrued.

Key words

Policy reform, National innovation systems, University-industry linkage, Public and private research, System measurement and assessment

1. INTRODUCTION

1.1 Overview

As the Japanese economy continues on its sluggish growth trajectory, reformers are pointing to Japan's innovation system as an impediment to growth. A particular focus of innovation reform has been the research and development (R&D) linkage between the university sector and private industry. The reform discourse argues that the engine of innovation now requires not only substantial sector-by-sector investments but an institutional matrix supportive of active linkages between these sectors as well. The rationale for this

perspective is the belief that R&D activities embedded in the university-industry nexus are becoming determinants of innovational competitiveness. This belief in turn follows directly from perceptions of significant innovative activity embedded in the university-industry nexus of the American economy via university patenting and licensure, faculty-driven firm formation, academic consultancy, and research contracting.

Although comparative analysis is a valuable tool in policy formulation, the validity of any comparison is constrained by the ability of its analytical framework to portray differing features of distinct systems accurately. This challenge is magnified in the case of embedded linkages because they are by nature diffuse and opaque, and in the case of innovation because its process is so enigmatic. Unfortunately, the analysis supporting Japan's ongoing innovation policy reform process has not met this challenge. Specifically, assessments have unjustifiably supported reform in the particular direction of the American innovation policy framework due to reliance on conventional wisdom rather than on critical analysis.

The errors of conventional thinking on university-industry linkage policies stem from fundamental differences between the policy models in Japan and the United States, and from the implications of these differences not being included adequately in standard analytical treatments. The United States and Japan differ in their policies for how to deliver social benefits to society from investments in public research. The Japanese policy framework is based on a "public model" in which public investments are intended to be complementary to private investment by focusing on areas subject to market failures. The policy framework in the United States, on the other hand, has evolved over the past three decades into a "quasi-market model." The model attempts to structure incentives for private individual and organizational gain in order to incentivize public research to contribute to industry and thus society. This analysis examines the implications of the distinct policy frameworks to the policy reform discourse, moving assumptions on the Japanese linkage into the assessment itself.

Based on these implications the analysis then re-assesses standard empirical measurements of linkage activity critically, so as to make comparative measurements comparable in substance as well as in name. The result demonstrates that the evidence generally taken by the conventional wisdom as indicative of a dysfunctional university-industry nexus in Japan is misconstrued. This finding is significant in that this perceived dysfunction is a major pillar of the ongoing reform process.

1.2 Defining the university-industry linkage

The linkage between the university and industry sectors is a broad nexus, encompassing a variety of interaction modes at different levels of hierarchy, scale, and scope. In alignment with its analytical objectives, the research adopts the following definition: *The university-industry linkage refers to the interaction between the university sector and the industry sector*

in the innovation process, with emphasis on the incidence of interaction rather than on its efficiency.

This choice of definition places outside the scope of the analysis the issue of efficiency: how efficiently does the Japanese innovation system translate investments in the university sector into economic gains in the industry sector. Accordingly, in a case such as inter-sector R&D funding, the analysis' interest is on using financial transfers to gauge the incidence of university-industry interaction in Japan relative to the United States, not on the relative economic returns from equivalent Japanese and American investments into university research.

The rationale for this definition is that the analysis' objective is to assess the linkage critically with respect to the conventional weak linkage view. Consequently, analysis must focus on the assumption driving the view: that the university-industry linkage in Japan is dysfunctional due to a disconnect between university and industry research. This is significant because the main thesis of the research is not that ongoing reforms aimed at improving the efficiency of the university-industry linkage in Japan are necessarily wrong. Rather, the thesis is that since reforms are based on the axiom of disconnect, their justifications are incorrect and subsequently a full accounting of potential costs as well as gains expected from reforms is not forthcoming.

It is also worthwhile to note here that although the efficiency issue is important, our understanding of the university-industry nexus is inadequate for a meaningful accounting of industrial returns on university investments. The innovation process is highly enigmatic, and not enough is known about the long-term effects of such revolutionary modes of university-industry interaction as university-based patenting and public-sector reliance on private sector funding. While we explore these more radical linkage modes, research also continues to indicate the utility of such comparatively reactionary linkage modes as an independent and open research system with free access to resulting knowledge. The empirical record suggests that this more traditional role of the university sector is an essential pillar of technological advancement (with fewer conflicts with the raison d'être of public research than more recent development-active roles). Its economic contributions, however, are diffuse and may be beyond direct quantification.

The implication of this choice of definition is that the use of a university-industry linkage metric such as coauthorship does not intend to suggest that university-industry coauthorship is a more efficient mode of linkage than other modes, for instance joint or contract research. It merely suggests that some metrics may present a less-biased or more policy-neutral measure of incidence of university-industry interaction than do other metrics. With the incidence of interaction at the heart of the analysis, the focus on such robust metrics is prudent (for details see Pechter 2001 UT, Pechter 2001 EMS, Pechter 2001 EAEPE, Pechter 2000 ISS, and Pechter 2000 EMS).

1.3 Why the university-industry linkage?

The focus on the university-industry linkage has occurred for a combination of reasons. First, intensifying innovation-driven competition in the market is demanding more of innovation systems, just as the barriers between markets and innovation systems themselves are diminishing and thus broadening the scope of competition. As this has occurred, the networked nature of the innovation process has captured the attention of business leaders and policy-makers, making the linkages between the various parts of national innovation systems the subject of competitiveness efforts. Of all the linkages in national systems of innovation, those involving the university sector are under particularly intense scrutiny. University resources are massive in terms of the sheer size of the investment of public resources in the university system and the opportunity costs of not placing these investments elsewhere. There is growing pressure to show a return on such enormous investment; especially in Japan where such pressure did not exist when the Japanese public was secure in its nearly four decades of postwar economic growth.

Second, now that the long-term growth period has ended, Japan is faced with making an economic transition from a stance suitable for postwar catch-up to one ready for continuing industrial leadership in the twenty-first century. One requisite of this transition is for Japan to play a leadership role not only in industrial innovation but also in fundamental research. For this reason, there are increasing expectations of strong academic sector performance, and transfer of the results of university research to society as a whole.

Third, one implication of Japan's transition is that the levers of industrial policy are less readily available than when Japan was an economically lagging satellite in the United States' Cold War defenses. Consequently, policy-makers are in search of levers to manipulate. Unlike private industry, which by definition is beyond the reach of many public policy instruments, the university sector, largely public in nature, can directly be adjusted through policy reform. As such, the university-industry policy framework makes for a good lever.

Fourth, as both a cause and an effect of increased competitiveness, the emergence of such fields as bio- and info-technologies have both amplified the importance of organizational networks in the innovation process and narrowed the gap between fundamental research and marketable products. For instance, network technologies not only compromise a large part of the products on the market today, but are also an important means for making today's products. New pharmaceutical products and advances in genetics are often on the university lab bench and the front page of the Wall Street Journal at the same time. In this context, the university-industry linkage is seen as a key nexus for new product and industry creation as well as for problem solving in existing industries.

1.4 The American influence

Opinion-leaders in Japan are aware of conditions in the United States, and follow them closely in shaping Japanese developments. In this context, it must be understood that the tremendous expectations placed upon the university sector in Japan come directly from the perception that universities in the United States have played a major role in building the strong American economy. Invariably, the standard of comparison for Japanese innovation policy is the United States. The U.S. makes a reasonable benchmark for Japan, considering that American universities and industry are at the forefront of many areas of research and innovation, and that due to historical circumstances the Japanese innovation system has been strongly influenced by the United States. Specifically, as Japan re-developed after the devastation of the Second World War, much of this development drive focused on "catching up" with the West, the United States in particular. This tendency to compare Japan to the United States has been amplified by the reversal of standing the two nations underwent in the last decade. Japan, whose come-from-behind postwar growth led it to overshadow the United States in many areas of innovation in the 1980s, transformed into an apparent economic laggard while the United States overcame its image of competitive complacency to advance into the new economy. In this context, the conventional wisdom sees the Japanese university-industry nexus as weak[1] (the research refers to this as the *weak linkage view*), and the American university-industry nexus as the exemplar of excellence. It is therefore understandable for Japanese policy-makers to seek duplication of American economic performance by emulating American policies.[2]

1.5 The resulting direction of university-industry linkage policy reform

The direction of policy reform resulting from the weak linkage view of the Japanese university-industry nexus juxtaposed against perceived American university strengths seems clear. Among policy-makers, industry leaders, and even university administrations and faculty boards, a broad consensus exists on reform of the Japanese university system, particularly its linkage to industry. While debate continues on the details, the general

1) Acceptance of the weak linkage view even within the ranks of academia is witnessed by such statements as the former Minister of Education and University of Tokyo president saying "Unlike the United States, there is very little interchange between Japanese universities and industry" (Arima 1997), or in the words of the president of the Science Council of Japan, "The two sectors have been segregated without communication or cooperation" (Ito 1997).

2) Because this research directly addresses the fact that developments in the United States specifically have been driving the Japanese reforms, it focuses on the United States-Japan comparison and not on other national comparisons that may be equally important and perhaps even more relevant to Japan's policy reform.

direction of reform is in accord: steps must be taken to improve the contributions of academic research to industrial development, and these steps should be towards the market-oriented activity common in the American university system. These activities include university-based patenting and licensing, faculty consulting to industry, firm formation leveraging university-created knowledge, and the reliance of university researchers on funding from the private sector. In order to grasp the tremendous sweep of agreement on these steps, we must consider the policy framework differences between the United States and Japan.

The framework that regulates how university assets interact with industry in Japan has been based on a public model of investment. In such a model university investments in research, particularly those of national and public universities, are intended to deliver benefits to society at large without concern for the needs of specific private interests. In fact, a research topic of direct interest to industry is considered best left to industry so that public resources can be brought to bear on other social goods that firms have less incentive to pursue. This is the market failure justification for public investment, and often applies to basic research that is deemed socially beneficial but too premature for commercial products. The emergence of this public investment model comes in part from the placement of Japanese education under the auspices of the national government—as opposed to its placement under state governments and the private sector in the United States. Furthermore, it has both reinforced and been reinforced by the wariness of close ties between the private sector and public research that grew out of Japan's wartime role and the policies of the postwar occupation forces (Hashimoto 1999).[3)]

3) At this point it is prudent to clarify the position of national universities in the context of the entire Japanese university system. Japanese universities are divided into national, public, and private universities depending on whether they were founded by the national government, prefectural or municipal governments, or by the private sector. Although the private universities are greater in number of campuses and students (Hirowatari 2000 p. 3), without question it is the national university system that is the most relevant to research and innovation. While national universities only account for about one-fifth of all students enrolled, they account for two-thirds of all graduate students (Organization for Economic Cooperation and Development 1998 URTCN p. 109) and three-fourths of all R&D expenditures (Kneller 1999 p. 310). Moreover, the research funding is by far concentrated in the top national universities. For instance, in recent years national universities have received on the order of ¥1.5 trillion of the lump sum the government allots to universities for special requirements like research and development, while public and private universities have received only ¥0.1 trillion ¥0.3 trillion, respectively (Hirowatari 2000 p. 3). Of the competitive research grants dispersed in by the Ministry of Education and the Japan Society for the Promotion of Science in fiscal year 2000, the top seven recipients were all national universities (the former imperial universities) and accounted for 42 percent of total disbursements; only one private university, Keio, was among the top twenty university recipients (Blanpied 2000 p. 3). It also important to keep in mind that the policies affecting national universities have a direct impact on private universities as well. Small relative to national universities as it may be, the amount of funding private universities receive from the national government is a substantial portion of private university funding, and the authority of the Ministry of Education over private universities is substantial as well. The salience of this is that in spite of a large private university system in Japan, from the perspective of innovation it is the public nature of the policy framework that dominates.

The result of this public approach has been an arms-length relationship between universities and industry, with university investment decisions at the individual researcher level insulated from profit-seeking incentives. Hence, university personnel have generally been prohibited from engaging in such profit-seeking activities as starting their own firms, accepting employment in the private sector, and selling (though not owning) university-generated intellectual property. The government has severely restricted the types of university research that firms may fund and has prohibited firms from hiring university personnel as consultants. In particular, the Ministry of Education (MOE)[4] has not engaged in profit-seeking with university resources, and has guarded its turf from the overt influence of industry and other ministries, especially the Ministry of International Trade and Industry (MITI).[5]

The policy framework in the United States is different from the one in Japan. Private universities play a much larger research role in the United States, as is evident from the stature of such eminent private research institutions as MIT, Stanford, Princeton, Harvard, and Caltech. As for public universities, putting military institutions aside, the United States has no national university system similar to the system in Japan. With the mandate of education constitutionally residing with state governments and with these states regionally dispersed, the American university system has developed into uniquely competitive situation (Feller 1999 p. 65, Etzkowitz 1999 p. 208). The federal government does support a tremendous amount of research in these universities. However, rather than this giving the American university system the feel of a national university system, the interplay between the federal funding agencies and the state governments and public and private universities creates a dynamism unknown in Japan.

Furthermore, although in concept the American university policy framework was once based on a public model and still is in many ways, to a large extent the framework has changed. In fact, it is no exaggeration to say that the university-industry linkage in the United States is has been undergoing a revolution (Etzkowitz 1999 p. 205). Starting in the late 1970s, legislation and subsequent amendments centering on the *Patent and Trademark Laws Amendments Act of 1980*—known as the "Bayh-Dole Act" for its bipartisan sponsors Senators Birch Bayh and Robert Dole—introduced market-oriented mechanisms into the American university policy framework. The new laws granted intellectual property rights

4) Due to its many name variations over the years in both English and Japanese (Ministry of Education, Science, and Culture; Ministry of Education, Science, Sports and Culture, or *Monbusho;* and currently Ministry of Education, Culture, Sports, Science and Technology or *Monbu-Kagakusho*), this article uses the designation "Ministry of Education" (or MOE) to refer to this ministry and encompass all name variations.

5) Although the government restructuring of January 2001 changed the name of the Ministry of International Trade and Industry to the Ministry of Economy, Trade, and Industry (*Keizai-Sangyou Shou*), considering the time frame of this study, from the early 1980 s to the present, the former name will be used throughout this article.

from federally funded research to universities, with stipulations to ensure profit sharing with faculty inventors. The move was in part a response to indications that less than 2-to-5% of federally funded research ever made it to commercial use (Office of Technology Alliances 1999 Appendix G, Hane 1999 p. 33). Considering that federal obligations for university science and engineering research alone in the 1970 s (not including fellowships, traineeships, instructional facilities, or R&D plants) averaged well over $2 billion per year (Division of Science Resources Studies 1997), it was considered that the public approach for generating social returns to research investments was highly inefficient.[6)]

The resulting framework aimed to improve the economic contribution of academic research through two inter-related incentives. First, through the incentive of profiting financially from their own research, university researchers would turn their attention to economically useful inventions. Second, by allowing universities to receive licensing royalties from the results of federally funded research, university administrators had the incentive to actively market these faculty-created inventions. These policy adjustments were catalysts for change as universities, responding to developments in science and technology such as the ascendance of info- and bio-technologies, increasingly ventured into market-oriented approaches. These approaches involved not only patenting, but also faculty consulting, venture capital utilization, and firm formation; activity this research collectively refers to as *university-based market-oriented activity*. What is truly revolutionary about this change is that while personal financial gain was once anathema, today's university researchers in the United States are increasingly compelled to demonstrate a positive bottom line in their research portfolios. The arms-length relationship between universities and industry has been replaced by a hand-in-hand relationship, as the policy framework governing the university-industry linkage in the United States has evolved into a quasi-market model.

In light of the policy framework differences between the United States and Japan, the recent policy trends in Japan are quite extensive. An Office for Promotion of Academia-Industry Cooperation has been established in the Industrial Policy Bureau of the Ministry of International Trade and Industry (Hashimoto 1998). Universities are being encouraged to set up technology licensing organizations (TLOs) to market university-generated intellectual property via patents universities receive on them. As of 2000, at least 16 technology licensing organizations have been set up on university campuses, with several more on the way (Takata 2000). National university professors, whose civil service status has prohibited them from consulting to private industry, are being permitted to receive payment for work outside of the university. Private sector research funding is not only being allowed onto the campus but is encouraged. Organizations like the Japan Science and Technology Corporation or JST

6) Current thinking is that selection bias led analysis to underestimate the level of actual commercialization, thus partly bringing into question the law's original justification (Mowery et al. 2001 p. 103 footnote 5).

(*Kagaku Gijutsu Shinkou Jigyoudan*) have even started sponsoring programs aimed at national universities and national laboratories to encourage the development of research into marketable products (*Shinki Jigyou Shikou-gata Kenkyuu-Kaihatsu Seika Tenkai Jigyou*), with university administrations acting as liaison between the faculty members and JST (Personal correspondence 2001). Endowed chairs have sprung up throughout the national university system, and there is even talk of the need for a "Japan-style Bayh-Dole Act" (*Nihon-ban Bai Do-ru Hou*) (Ministry of Education, Culture, Sports, Science, and Technology 2001).

Given that university-based market-oriented activity has hitherto been anathema to Japanese universities and still is for the most part, this is a remarkable sweep of agreement.

2. PROBLEMS WITH THE CONVENTIONAL REFORM RATIONALE

2.1 Thesis statement

There nothing wrong with Japanese policy-makers reformulating the university-industry policy framework to meet current needs, and in fact the policy framework is unquestionably in need of reconsideration. Many of the principles in the foundation of the original policy framework were born in a world much different than the one Japan faces today and are in need of reconfiguration, as are the institutions of innovation that evolved during Japan's long-term growth period. This research does not assert that these policy changes are all necessarily incorrect. *The thesis of this research is that the problem with the reforms is that they are based in large part on assumptions regarding the American and Japanese innovation systems rather than on critical analysis; as a result, a full accounting of potential and benefits of reforms is not forthcoming.*

Simply speaking, if the university-industry linkage in Japan is weak and a strong university-industry linkage in the United States is propelling the American economy, it would be difficult for policy-makers to resist the logic that the university-industry linkage in Japan should be strengthened and that the United States provides the model for doing so. Compelling as the argument is, however, it is unsound. In essence, the argument says that the Japanese university-industry linkage is dysfunctional, and the American policy framework provides the solution, and this may indeed be true at certain levels. The problem is that rather than assessing the merits of current policies and alternative policy options, the perception biases from both the American and the Japanese perspectives have led to blanket assumptions that difference equals inferiority. In other words, simply showing that the Japanese innovation system exhibits a lower level of some activity than the United States does is taken as an argument for adopting policies to increase that activity. This occurs in such cases as university-based patenting and university sector reliance on private sector funding, where it is generally assumed that higher levels of such activity in the United States is proof of

dysfunction in Japan. The key problem is that in the process, the issue of the merits or the activity itself are often not even mentioned as a relevant issue.

Making matters worse, due to axiomatic acceptance of the assumptions, the initial claims that the U.S. exhibits higher levels of the activity than Japan does are often themselves neither empirically measured nor analyzed critically for accuracy. This failure of analysis is especially important in the case of embedded linkages due to the opaque and diffuse nature of their operating routines; in the case of cross-country comparisons where distinct institutional environments are structured differently due to state policies, cultural norms, and social and political interactions; and in the case of a process such as innovation with so little theoretic codification of practice.

2.2 The standard rationale for policy reform

A rather simplistic argument has emerged as the standard rationale for Japan's policy about-face. On one hand, the rationale goes, Japan's investments in university research are large and comparable to those of other leading countries. For example, academic R&D expenditure is on par with other advanced economies and the number of university researchers is a large component of the total researcher population in Japan. On the other hand, in spite of these ample investments university outputs are small: e.g., university-held patents, spin-off firms from universities, and various forms of university-industry tie-ups. It is important to note that these are precisely the phenomena attracting attention in the United States.

Then director of MITI's Office for Promotion of Academia-Industry Cooperation provided an example of the standard rationale in the *Journal of Japanese Trade & Industry* through an article titled "Desirable Form of Academia-Industry Cooperation" (Hashimoto 1998). The argument points out the ample investment in the Japan's university research system and stresses that in 1994, university researchers comprised 36% of all researchers in Japan but only contributed 129 patents or 0.04% of all Japanese patents. The argument also portrays American universities as the benchmark, receiving 1,862 patents.

Note that this argument is not a MITI-centered construct. Japan's Federation of Economic Organizations (*Keidanren*) announced the identical argument through a policy statement in the form of an "Urgent Proposal" (***Kinkyuu Teigen***) in 1998 (Federation of Economic Organizations 1998). The argument appeared in a recent, influential book on the subject of university reform edited by one of Japan's most prominent economists with faculty experience in both the United States and Japan (Aoki et al. 2001). It has even reached the popular press, appearing prominently in the investor issue of the popular business journal *J@pan Inc* (Kawakami 2001 p. 42). Another line of argument concerns the comparison of the flow of R&D funding from the private sector to universities. It claims that industry-to-university R&D funding flow in Japan is meager compared to the United States, and that this meagerness is

both evidence of the weak university-industry linkage in Japan and a justification for increasing the flow. This argument has appeared in such prominent positions as a key chapter by the research director at the Ministry of Education's National Institute of Science and Technology Policy in the Japanese university policy reform book (Sakakibara & Ijichi 2001) and in the keynote address to the March 2001 meeting of the Japan Association for Evolutionary Economics by one of Japan's foremost science and technology policy analysts (Miyazaki 2001). Table 1 and Table 2 depict these arguments in tabular form.

The arguments thus judge the university-industry linkage in Japan to be weak based on low output-to-input ratios, and on the meagerness of Japan in comparisons of such metrics as R&D funding flow, university-held patents, and royalties from these patents. With these definitions of weakness, the approach to strengthening the linkage is clear: increase university dependence on the private sector for research funding and increase university involvement in patenting and licensing activity. In other words, Japan must change its university-industry policy framework to encourage American-style, market-oriented activity.

Table 1. University percentage of Japan totals

Sector	R&D	Researchers	Patents
University	20%	35%	0.04%
Others	80%	65%	99.96%

Table 2. Comparison of common linkage metrics

Metric	Japan	U.S.
Industry-to-University R&D Funding Flow	72 bil yen	346 bil yen
University-held Patents	129 patents	1,862 patents
Royalties from Patents	0.03 bil yen	57 bil yen

While this argument for change has tremendous appeal in today's sluggish Japanese economy, it is logically flawed. The flaws stem from two sources, one prescriptive (or normative) and one descriptive (or positive). The prescriptive error results from prescribing an increase in some type of university-based market-oriented activity like patenting when the issue of whether university-based patenting is expected to generate net positive returns is not considered or even mentioned as relevant. It is illogical to interpret the larger American university patent pool as a rationale for change unless it is first decided that university patenting itself is desirable. The same thing can be said about such other market-oriented adaptations as private sector funding dependence. We will consider the desirability of the American pro-patent policy framework in a moment, but suffice it to say that the policy discourse generally does not even bring up the issue, let alone demonstrate it.

The descriptive error stems from using a comparative scarcity of a policy-dependent activity like university-held patents in Japan as a measure of university-industry linkage performance. Since the American framework has been market-oriented for years while the

Japanese framework has been based on a public model, we expect ex ante that American universities will hold more patents than will Japanese universities. In fact, before even making such a count we can say with certainty that we would be surprised if it turned out that American universities did not have higher patent counts than Japanese universities. American universities have been activity pursuing pro-patent policies since at least the implementation of the Bayh-Dole Act in 1980. Active revenue generation from patent portfolios is a major feather in the academic cap at nearly any American university. In Japan, the university system has been till now decidedly uninterested in the pursuit of patenting revenue. Given this situation, the disparity in patent counts between American and Japanese universities is more an indicator of respective policy frameworks rather than of differing levels of performance by actors in congruous systems. As patent activity differentials are more a function of policy framework differences than system performance, it is illogical to interpret a lesser amount of university-held patents as an indicator of weakness in the Japanese university-industry linkage. In short, the descriptive error is to use a university-based market-oriented activity differential to describe Japan's university-industry linkage as inferior, and the prescriptive error is to use the differential as a rationale for increasing such activity. These errors have continued unchecked due in large part to the widespread and axiomatic assumption of the conventional weak linkage view of Japan's innovation system.

The failure of the standard rationale has a major lesson: rather than starting from assumptions, policy formation must be supported by robust assessments that critically assess underlying assumptions with empirical measurements. This includes both assumptions concerning the state of the policy system in question and of potential alternative policy models. We will later pick up on this lesson by re-assessing the claims that the university patenting and university-industry R&D funding flow metrics indicate the Japanese university-industry linkage to be dysfunctional. Before doing this, however, it is illuminating to consider the record of the Bayh-Dole regime in the United States.

2.3 The record of the Bayh-Dole regime

The above discussion demonstrates that the issue of the desirability of university patenting is key to the policy reform discourse. Rather than explicitly considering it, however, the Japanese policy reform process rests instead on the assumption that university-based market-oriented activity in the United States has been a key factor in American economic growth and as such forms a net benefit. Critical analysis, however, demands that policy-makers ask the question: Does a pro-patent policy framework like that in the United States provide clear positive net returns? This is a major research question, the ultimate answer of which is beyond the scope of this article. It appears clear, however, that the answer is not a simple "yes."

Although surprisingly little empirical analysis has been done on this issue, one such analysis

took place as part of a University of Tokyo-Harvard University joint study, *Universities and Science-Based Industrial Development: A Comparative USA and Japan Dialogue on Public Policy for Economic Development* (Branscomb et al. 1997-1999). In a seminal chapter from the book which encapsulates the study's findings (Branscomb et al. 1999), Mowery et al. demonstrate empirically that much of the rise in academic patenting over the past three decades in the U.S. resulted not from the Bayh-Dole Act, but from changes in research and inventive activity associated with emerging fields such as biotechnology, and an array of developments in research, technology and industry (Mowery et al. 1999). Rather, where Bayh-Dole did have a major impact was on the marketing efforts of universities, as universities greatly expanded resources for the licensing of intellectual property. While this outcome was intended, its downside is that knowledge that would have been in the open public domain has instead been kept closed as proprietary knowledge.

Whether or not the new American framework has increased the social returns of academic sector investments is an open question. Improved returns may have been generated by linking extant academic sector knowledge to business development, steering academic researchers toward industrially beneficial research, incentivizing academic researchers toward research excellence, and putting university educators better in touch with "real world" needs. Yet we must also consider the costs of the new framework. These include leading academic researchers away from important though financially non-profitable research, retarding knowledge diffusion by transforming open knowledge to proprietary knowledge, and diverting the focus of would-be educators to profit-seeking activities. Moreover, in follow-up research Mowery et al. had this to say about the premise that patents and exclusive licensure are the best approach to maximizing returns on R&D investments (Mowery et al. 2001 p. 118):

> This premise appears to understate the effectiveness of publication and other, more open channels for information dissemination and access in enabling society to benefit from publicly funded academic research. Indeed, a recent survey of firms in the manufacturing sector indicates that the four most important channels through which firms benefit from university research are publications, conferences, informal information channels, and consulting (Cohen et al., 1998). Even in pharmaceuticals, where patents and licenses are more important than in other industries, firms rely heavily on these other channels of knowledge and technology transfer (Gambardella 1995).

The upshot is that while there may be certain benefits to the university patenting mode of knowledge and technology transfer, it is not at all conclusive that these benefits outweigh the benefits of traditional modes of transfer.

In addition to not clearly providing a superior channel of development over more traditional public model modes of development, the Bayh-Dole regime may be generating some chilling costs. The transformation of the traditionally open culture of academic research to one in which every researcher is potentially an entrepreneur may put a freeze on the free exchange and challenge of ideas which has hitherto been the lifeblood of the search for knowledge. Stories of university researchers hoarding their specimens, delaying the publishing of results or doctoring their results so as not to invalidate patent claims, and otherwise

turning away from the ideal of openness are so prevalent now in the United States that they are even reaching the popular press. For instance, in a recent article titled "Science Failing to Share," *Newsweek* reported a survey in which nearly half of geneticists surveyed had been denied information, data or materials (Newsweek 2002). While the desirability of university patenting will likely vary depending on the location and field, one thing is certain: the move to a market-oriented framework in the United States has not been cost-free. This fact is often neglected in the standard rationale of Japan's university-industry linkage policy reform.

Moreover, even if American conditions were critically assessed to show that the American approach has provided a net benefit to the United States, it is not a given that the same benefit would accrue to Japan. The quasi-market model of the American university system has undoubtedly been enabled by an American value system and initial conditions different from the value system and initial conditions that led to Japan's policy framework. If these value system differences continue to exist, it is not certain that the costs of a quasi-market model would be acceptable to Japan. Moreover, Japan's distinct environmental constraints (e.g., history, location, etc.) together with the path dependence of Japan's particular industrial development trajectory may prevent transplantation of the American approach to Japan. Masahiko Aoki's research on comparative institutional analysis led him to describe this situation by saying that "institutional structure is like a big puzzle" in which "attempts to arbitrarily replace pieces one by one will result in a loss of integrity of the whole picture" (Aoki 2000 p. 58). As a result, he concludes (ibid. p. 132):

> Not only is it unrealistic, therefore, to try to remodel the Japanese economy on the Anglo-American system, but it would be counterproductive to the pursuit of economic gains from diversity.

Aoki asserts that discovering the source of economic gains from diversity requires analytical tools suitable to an "economics of pluralism" (ibid. p. 1). In other words, approaches to system analysis must enable assessments that appreciate system diversity rather than assume it away.

The implication of this is that policy reform must be based not on simplistic comparisons, but rather on the assessments of both policy alternatives and of the state of the university-industry linkage under current policies. This requires critically assessing the conventional wisdom based on empirical measures.

3. MEASURED ASSESSMENTS OF THE CONVENTIONAL WISDOM

3.1 The root of the problem

In the context of the different policy frameworks mediating the university-industry linkages in the United States and Japan, it is clear that output indicators of activity directly regulated by the respective policy frameworks (e.g., university-held patents and industry-to-

university R&D funding flow) are not accurate metrics of linkage performance (i.e., cross-country comparisons of such indicators are not surrogate comparisons of cross-country quality of performance differentials). Why then, we are compelled to ask, have they taken such a dominant position in the ongoing reform discourse? The root of the problem is that the preconceived perception of weakness in the Japanese university system has been driving the reform process. Rather than concluding the university-industry linkage in Japan to be weak based on a consideration of key metrics, it may be more accurate to say that the preconceived assumption that the university-industry linkage in Japan is weak has determined how to consider the metrics.

For this reason, it is necessary to critically re-assess what these metrics say about the university-industry linkage. This section does this for the issues of the patenting of university-generated knowledge and of industry-to-university inter-sector R&D funding.

3.2 Patenting of university-generated knowledge

The input-output models used in conventional assessments of the university linkage fail to capture the true innovativeness of a national system. For instance, university patenting is only one way to transform knowledge into marketable technology, and a relatively recent one at that. Patenting, the granting of a limited monopoly for the sake of encouraging the investment needed to develop an idea into a product, is anathema to the traditional role of public research. Rather, it was originally intended for the results of public research to be transferred free of charge to private industry for development. While the traditional modes of transfer—university education, academic presentation, scholarly publication—may be turning out to be too limiting to the demands of some of today's technologies and competitive markets, there are ample other development modes in addition to university patenting that also must be considered. These include interactions embedded in trade associations and industry groups, participation in deliberative committees, membership in study groups (*kenkyuukai* in Japanese), human resource transfers, personal contacts, and all manner of joint research in which university researchers do not claim rights to the resulting intellectual property. Each of these modes may allow the transfer of knowledge and technology without the university or its employees retaining patents. Although the weak linkage view of Japan describes these modes pejoratively as "under the table" technology transfer, we must acknowledge that this type of transfer is closer to the traditional role of public research than the recent emergence of university patenting is.

This article's discussion has already deduced that lower university patent counts do not necessarily indicate a weakness in the Japanese university-industry linkage, nor do they necessarily argue for an increase in university patenting (this must instead be based on an assessment of the merits of university patenting itself). Now let us consider the measurement context of these patent counts. Is it possible that Japanese university research is actually

resulting in patents that do not show up in these patent counts?

Contrary to popular belief, in spite of the prominence of the Bayh-Dole Act, Japan may actually have fewer prohibitions against the acquisition of intellectual property rights by university personnel than the United States does. Note that this pro-patent aspect does not contradict the earlier statement of this article that Japanese universities are based on a public model that discourages university patenting. The pro-patent aspect exists not in order to facilitate development of new products but rather out of deference to the highly valued right of academic independence in Japan. Furthermore, the effect of the national status of Japan's leading research universities is that unlike the American policy framework in which the policies are structured to incentivize the universities to play an active role in the patent and licensing processes, the Japanese policy framework has if anything removed the university (and thus the nation in the case of national universities) from the entire patent decision in most cases. The result is that rather than the Japanese policy framework promoting transparent academic patenting on the institutional level as in the United States, it instead promotes opaque patenting activity and transfer of inventions outright by university personnel on an individual basis. We therefore expect ample cases of the patenting of university-generated knowledge that would not show up in the public record.

As it turns out, there is strong empirical support for these expectations. For instance, Yoshihara and Tamai report that the University of Tokyo officially recorded only 3 patents for the entire university in 1996. Meanwhile domestic patent market analyst Diamond Management Development attributed 98 patents to the University of Tokyo, and a survey by the University of Tokyo Faculty of Engineering for the same year indicated that about 150 patents filed that year listed engineering faculty members as inventors (Yoshihara & Tamai 1999). Kneller estimates that industry patenting of university inventions may be as much as 1000 or more patents annually, and adjusting for size differences between the United States and Japan concludes (Kneller 1999):

> ... the number of patentable Japanese university discoveries transferred to industry is probably not remarkably less than in the United States.

Thus we have a picture in which Japanese university patenting, although not necessarily equal in number to university patenting in the United States, is by no means as scarce as official statistics portray it—and Japanese university research nowhere near as irrelevant to industry as the conventional wisdom holds it to be.

3.3 Inter-sector R&D funding

We can also look more critically at R&D funding flow. The first item of notice is that like university patenting, R&D funding flow is also under the direct influence of the respective policy frameworks in the United States and Japan. Because the Japanese university-industry policy framework is based on a public model while that in the United States is based on a

quasi-market model, we expect from the outset that American universities will be more reliant on private sector funding than Japanese universities will be. This means that even if a comparison of R&D funding flow in the U.S. and Japan were to determine that the flow is higher in the United States, this does not necessarily mean there is a problem with the functioning of the Japanese system. By design, the public model Japanese university system should be less dependent on the private sector for funding than quasi-market American university system is. The justification for reform of this situation is not found in a comparative difference in current funding flow levels, but in assessment of the merits of university reliance on private sector research funding.

Rather than supporting this level of analysis, the conventional weak linkage view creates an environment in which the assumption of weakness determines how to interpret the data rather than the other way around. For instance, based on the weak linkage view observers of the Japanese innovation system have been quick to diagnose a faltering of industry support of university R&D. They site such evidence as the lack of growth in the amount of R&D funding flow from industry to universities, and the decline in industry R&D support as a percentage of overall university R&D (see for example Sakakibara & Ijichi 2001). There is no question that this evidence is correct; the problem lies in the interpretation of the evidence. The stagnation in the amount of industry-to-university R&D funding flow is actually a result of the stagnation in overall industry R&D expenditure due to the sluggish economy of the last decade. In spite of industry's stagnant overall R&D investments, however, the percentage of industry's R&D investments going to the university sector has continued to rise, and at a rate faster to any other sector (Pechter 2001 UT Chapter 3, Pechter 2001 EAEPE, Pechter 2001 EMS).

Furthermore, the decline in industry R&D support as a percentage of overall university R&D has been due not to a decline in industry interest in the university sector, but rather due to the fact that government has managed to boost university R&D spending after years of poor growth even while the industry sector has been mired in economic sluggishness. The result is that the decline in industry component of university R&D comes from the growth in university sector R&D relative to industry sector R&D, not due to a weakening of the university-industry linkage. In fact, accounting for university sector-industry sector relative size dynamics, the growth in industry support for university R&D in Japan has been much greater than in the United States: a tripling in Japan over the 1979-1996 period compared to a doubling in the United States (ibid.). Thus, the real reason for the decline has not been a weakening of the university-industry linkage in Japan, but the failure of national investments in the university sector in Japan to keep up with overall economic growth, as in the United States. The issue is therefore not one of the linkage between the university and industry sectors, but one of fundamental policy choice in how Japan chooses to run its university system and support fundamental research (for more on fundamental research investments see Coleman 1999). The axiomatic nature of the weak linkage view obscures this reality.

With care taken to avoid drawing unfounded conclusions, it makes perfect sense to attempt

to compare industry-to-university R&D funding flow in the United States and Japan. However, as valuable as R&D expenditure metrics can be, in the case of R&D funding flow comparisons they are quite problematic from the perspective of system measurement errors. To begin with, as a gauge of efforts to enlarge the knowledge base, formal R&D expenditure is only a small fraction of all inputs into knowledge creation. R&D draws from many sources, including informal professional exchange, experience, and so on. Furthermore, there may be sources of R&D expenditure that do not make it into official statistics (Organization for Economic Cooperation and Development 1996 p. 32), while "university R&D statistics are notoriously difficult to compile and may be seriously flawed" (Organization for Economic Cooperation and Development 1998 URT p. 26).

In order to gauge funding flow differences, we can consider existing official U.S.-Japan comparisons by authorities mandated to track national R&D statistics. While there are many cases of international comparisons of R&D expenditure statistics in general, there are very few examples where sanctioned international comparison has been carried out specifically on industry-to-university R&D funding flow. In these few cases, the authorities concerned attempt to perform conversion and comparison in a manner aimed at reducing uncertainty stemming from differences in the underlying data. These approaches range from simple ratio comparisons within each country's currency separately to conversions to a common currency. For our purposes, we will consider comparisons by an American agency (the National Science Foundation or NSF), a Japanese agency (the National Institute of Science and Technology Policy or NISTEP), and a multinational agency (the Organization for Economic Cooperation and Development or OECD).

Table 3. Industry-to-university R&D funding flow as a percentage of industry and university R&D

Industry% (1996)

	Japan	U.S.	Japan/U.S. Ratio
NSF	0.5%	1.5%	0.3
NISTEP	0.7%[a]	1.4%	0.5
OECD	0.7%[a]	1.4%	0.5
Original	0.7%	1.0%	0.7

University% (1996)

	Japan	U.S.	Japan/U.S. Ratio
NSF	2.3%	7.0%	0.3
NISTEP	2.3%[a]	5.8%	0.4
OECD	2.4%[a]	5.8%	0.4
Original	4.0%	4.4%	0.9

[a] Japanese data from NISTEP and OECD are for 1995.

These agencies all indicate the university-industry funding flow in Japan to be much lower than in the United States, as witnessed by the fairly low ratios of Japanese-to-American flow percentages. However, all of these comparisons ignore fundamental differences in statistical definitions and data collection methodologies, and institutional incongruities (for more on this see Pechter UT 2001). Therefore, in addition an original comparison has been added based on adjustments to make the two countries' data even more comparable (see Appendix A for the methodology). Where the official comparisons displayed Japan/U.S. ratios on the order of 0.3

to 0.5, the original comparison displays Japan/U.S. ratios in the range 0.7 to 0.9. In other words, rather than the level of funding flow in Japan being one-third the level of funding flow in the U.S., we see that data indicates the level to be closer to three-fourths the U.S. level. We can only surmise that the conventional weak linkage view of Japan has facilitated the persistence of these inaccurate comparisons.

Thus we again have a picture in which Japanese inter-sector R&D funding flow, although not necessarily equal to the United States, is by no means as scarce as official statistics portray it—and Japanese university research nowhere near as irrelevant to industry as the conventional wisdom holds it to be. At the very least, the this analysis supports the finding of a well-functioning university-industry linkage in Japan from the perspective of the incidence of interaction.

4. TOWARD MORE ROBUST ASSESSMENTS

4.1 A policy-neutral metric of the university-industry linkage

The previous sections demonstrated that the university-industry linkage modes of university patenting and university reliance on private sector funding cannot be said to provide clear advantages over more traditional public model modes; nor are they themselves direct measures of the university-industry linkage. This counters the claim that the comparative scarcity of such activities in Japan is sufficient justification to increase such activity. Furthermore, critical analysis of these activities taking into account institutional differences and functional equivalencies demonstrated that in fact the perceived comparative scarcities themselves are overstated. Still, the fact that the metrics used in these comparisons are biased in favor of the American system makes direct comparisons difficult. What is needed is a metric that is policy-neutral and directly measures the university-industry linkage.

Based on these lessons, this section comparatively assesses the university-industry linkage in Japan and the United States using the more robust metric of university-industry coauthorship of scholarly publications. Coauthorship analysis looks at university-industry research collaboration in Japan through the window of coauthored articles. Specifically, the analysis characterizes the university-industry linkage by analyzing events in which an article published in the peer-reviewed science and engineering literature was submitted by at least one author affiliated to an industrial enterprise jointly with at least one author affiliated to a university. This is a fruitful approach because coauthorship is an indicator of a broad range of collaborative activity, and may result from collaborations involving the flow of either financial, capital, human, or intellectual property resources. In fact, coauthorship may even occur when there is no flow other than that of ideas. Furthermore, unlike such mass data as R&D expenditure statistics, the parties to individual collaborations are identifiable in bib-

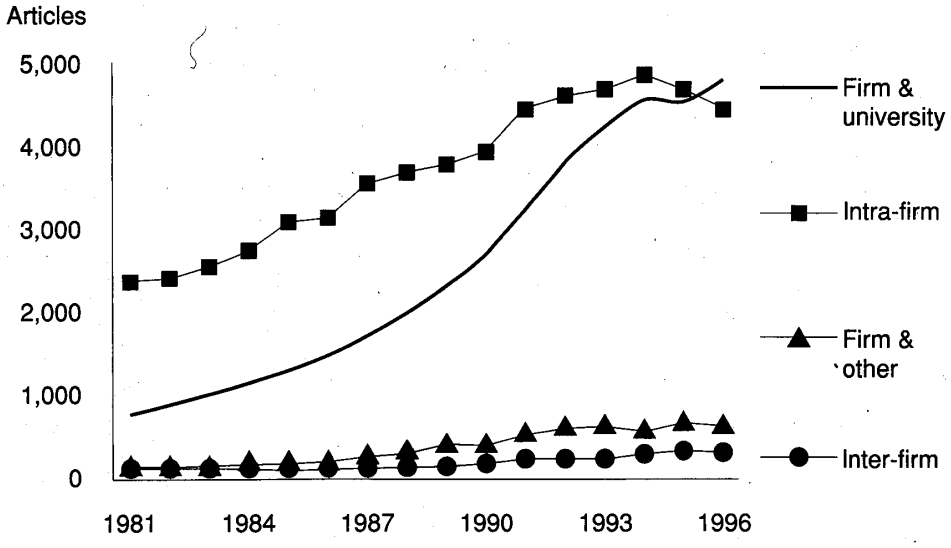
liometric databases; this affords a more detailed view of the innovation system.

More importantly, because the policy framework does not regulate coauthorship directly, the coauthorship metric measures performance of the system rather than the policy framework of the system. In other words, there are no regulations or legislation prohibiting university-industry research interactions, unlike prohibitions on university-based market-oriented activities. This is especially important for international comparisons. Although within the constraints of a given policy framework university-based market-oriented activity metrics do measure the performance of the system in question, when comparing systems with different policy frameworks it is not possible to know how much of the variation between systems is due to bottom-up performance differences and how much is due to top-down policy variations. The coauthorship metric does not have this limitation.

4.2 Coauthorship analysis

Based on the methodology of Appendix B, Figure 1 shows the articles produced by Japanese industry from 1981 to 1996.[7] These articles are divided into intra-firm articles (articles by a single industry author or multiple authors within a single firm), inter-firm articles (articles by authors in different firms), university-industry articles (articles by authors from both the industry and university sectors), and articles by authors in the industry sector and organizations in the "other" category (primarily national laboratories, public corporations and non-university hospitals). Note that by definition all these articles have at least one industry author, and so the sum of the four lines equals total industry publication. The data contain both domestic and international collaborators of the Japan-based firms.

Figure 1. Japanese industry articles by mode of interaction



7) Parts of this section are based on joint research with Sumio Kakinuma of the Ministry of Education, then of the National Center for Science Information Systems (for example, Pechter & Kakinuma 1999 EMS, Pechter & Kakinuma 1999 MIT, and Kakinuma & Pechter 1999).

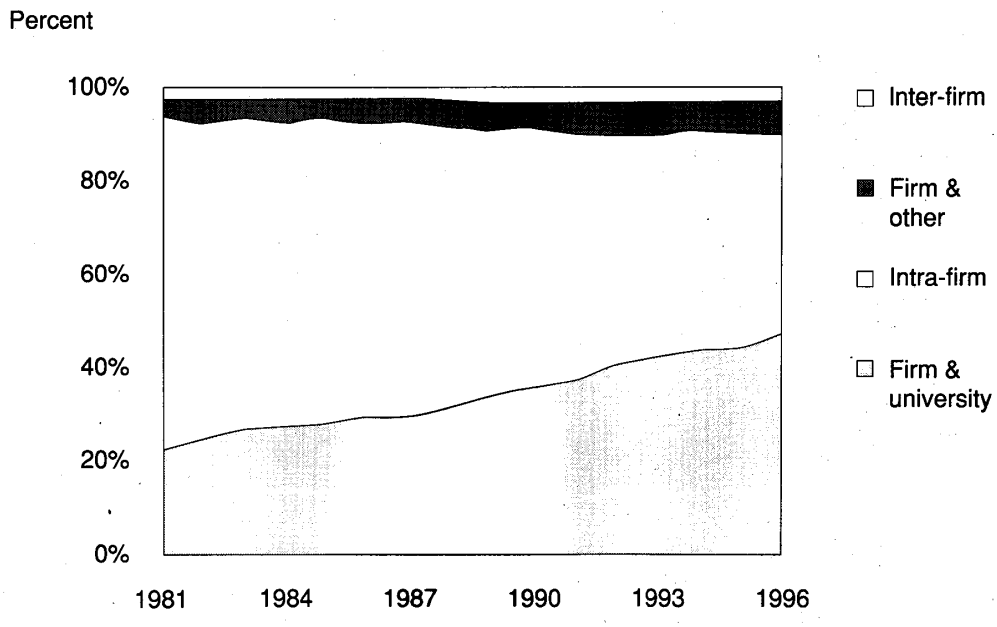
The first thing the figure shows is that university-industry coauthorship is by no means a minor mode of the innovation process. Of the total 110,588 industry articles over this period, fully 37% of these were coauthored with university authors. This compares with only 3% for inter-firm articles. Low inter-firm coauthorship is not necessarily surprising, considering that inter-firm collaboration is likely to involve proprietary information not suitable for publication; but it does undercut the taken-for-granted view and anecdotal evidence that suggest university research labs are of little interest to industrial researchers in Japan.

The second thing the figure shows is that that over the time period of the study, university-industry coauthored articles rose more than any other mode of publication. In 1981, 70% of total industry articles were intra-firm articles, but by 1996 this had dropped to 43%. Conversely, articles authored jointly with university researchers went from 23% in 1981 to 46% in 1996, overtaking the intra-firm mode of publication. This ratio of university-industry coauthored articles to total industry articles is a principal metric of the university-industry linkage, called the *coauthorship ratio*.[8] The coauthorship ratio measures the percentage of industry publication that is coauthored with a university researcher. By comparison to the coauthorship ratio, the portion of articles authored jointly with another firm held roughly constant at about 3%, while articles coauthored with the "other" category rose from 4% to 7% over the period. Figure 2 shows the percentage breakdown of interaction patterns.

Coauthorship analysis reveals that university-industry research interaction as measured by publication trends has:

- not only been a significant mode of the industrial research process, but also
- this significance has intensified dramatically over the past two decades, in fact doubling on

Figure 2. Japanese industry articles by percentage of interaction mode



8) When the word "coauthorship" appears without the modifier "university-industry," it is understood to refer to university-industry coauthorship.

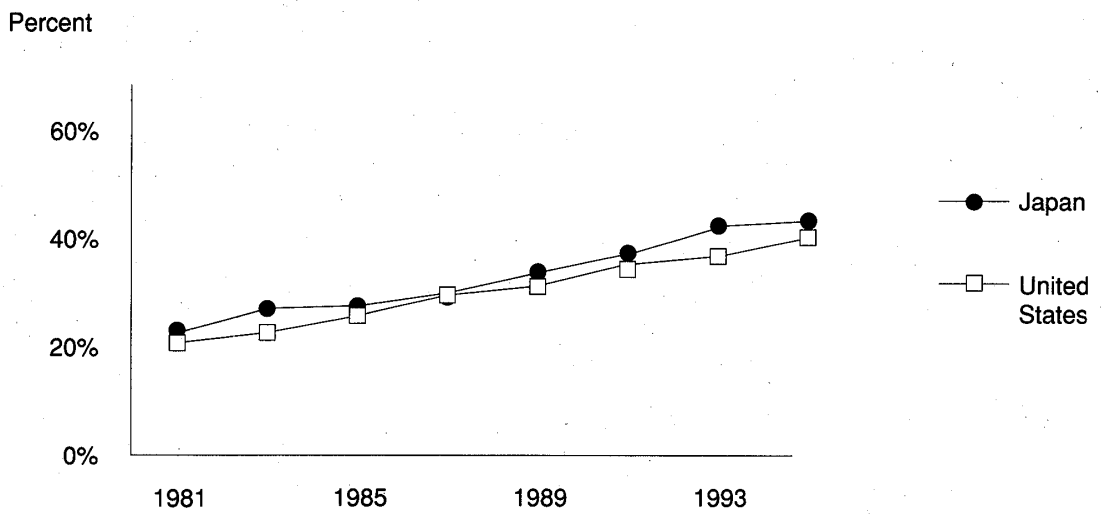
a percentage basis, thus

• overtaking intra-firm research as the dominant mode of industrial innovation.

As such, the coauthorship metric enables us to see the important role that the university-industry linkage plays in Japanese innovation.

Given that comparisons with the United States have been driving much of the policy reform discourse in Japan, it is natural to ask: How does the university-industry linkage in Japan as measured by coauthorship compare with that in the United States? To answer this question we turn to data in the U.S. National Science Foundation's *Science & Engineering Indicators-1998*, which measures coauthorship in the United States based on a methodology similar to the analysis of Japan (National Science Board 1998). Figure 3 shows the coauthorship ratio for both Japan and the United States.

Figure 3. University-industry coauthorship ratios in Japan and the United States



It is clear from the figure that the United States and Japan display a remarkable similarity to each other. In fact, the university-industry linkage measured by the coauthorship metric is essentially the same for Japan and the United States. Furthermore, considering that the coauthorship ratios in both countries have grown dramatically—both doubling over the 16-year period of the study—it is remarkable that the linkages in both countries have changed at the same rate. Thus, in spite of anecdotal evidence to the contrary, the empirical evidence suggests that industry and academia in Japan interact in the research process at least as much as in the United States. Although methodological differences must be considered before making strict comparisons, the fact that this study and the National Science Foundation data are based on the same data source and the same methodology lends credibility to this comparison.

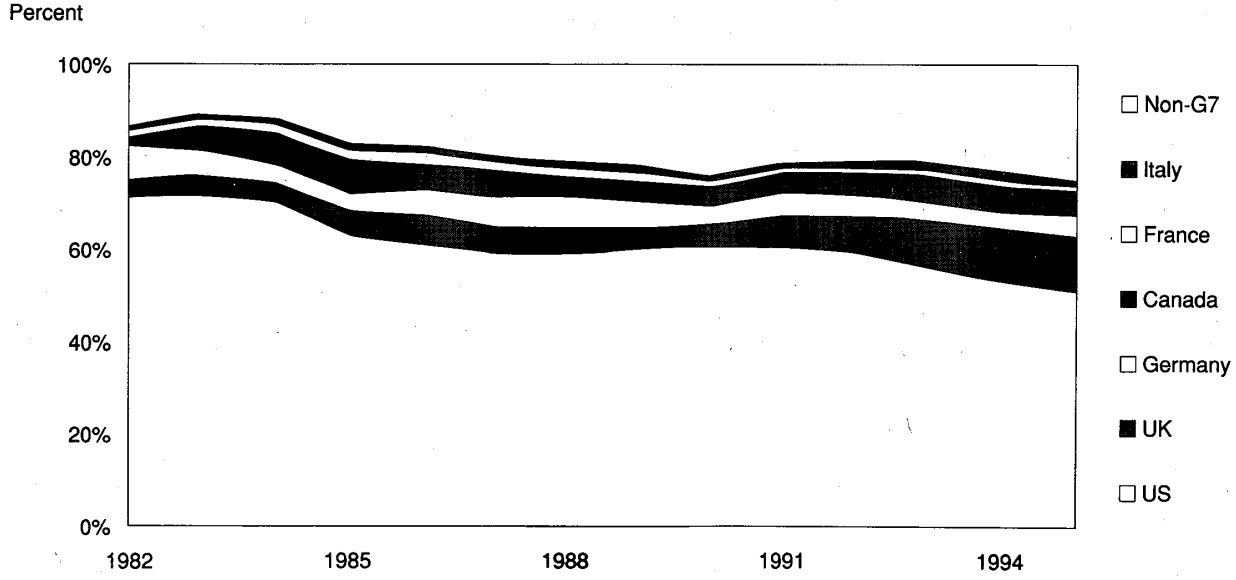
Given the strong coauthorship performance in Japan, the conventional wisdom explanation for it is that the rise of Japanese industry coauthorship with academia simply indicates the growing importance of American university research to industry in both countries. In other

words, this explanation says that the Japanese industry linkage is to American universities rather than to Japanese universities. It is true that American universities represent the most active partner country to Japanese industry. From 1981-1996, 62% of foreign coauthors have been in the United States, followed by 9% in the United Kingdom, 6% in Germany, 5% in Canada, 2% in France and 1% in Italy. The total for non-G 7 countries is 23% (the percentages add up to over 100% due to articles coauthored with researchers in more than one country).

At first glance, this may appear to support the assertion that Japanese industry is highly dependent on U.S. academic research. However, if we look at each country's component of total foreign coauthorship on a percentage basis, we find a different story. Figure 4 shows the foreign component of coauthored articles disaggregated by location of the foreign university researcher and shown by percentage of total (it does this with a three-year moving average in order to enable us to focus on the long-term trends instead of year-to-year spurious variation).

The figure shows that the growth in coauthorship has not been driven by growth in coauthorship with the United States. In fact, the portion of coauthorship in which an American university researcher is the collaborator has been declining steadily over the period of this study, with non-G 7 countries growing the most. As a percentage of all foreign collaboration, coauthorship with the United States has dropped, from a high of near 80% in 1983 to near 50% in 1996. Over the same period, coauthorship with university researchers in the non-G 7 countries went from about 10% to nearly 30% of all internationally coauthored articles. While it can only be speculated that some of this rise is due to the move of Japanese firms abroad due to the rising yen and trade friction as well as the growth of innovative competitiveness in many regions throughout the world, what is certain is that the empirical evidence does not support the hypothesis of Japan's growing university-industry linkage resulting from increasing dependence on the United States as a source of university research.

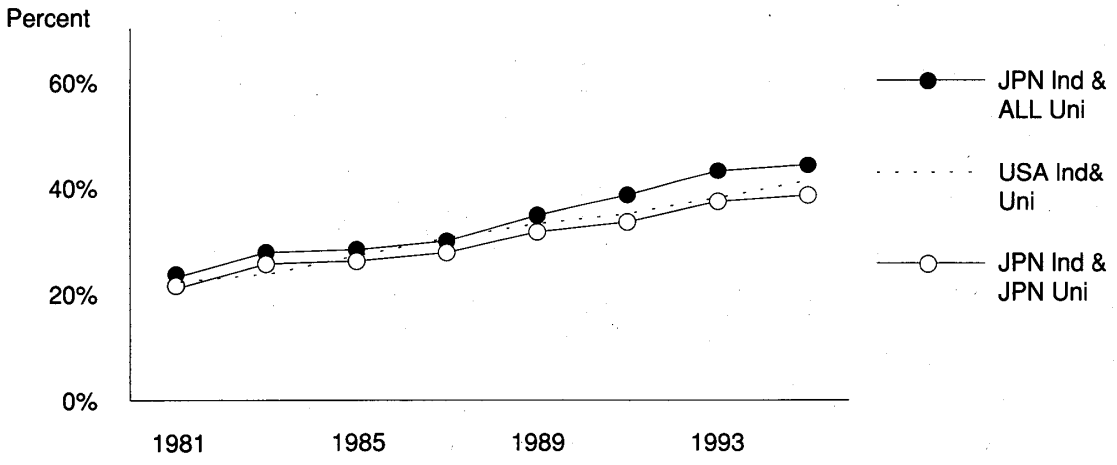
Figure 4. Percentage of Japanese coauthored articles by location of foreign university collaborator



As a final and stringent test of this hypothesis, we can consider the Japanese coauthorship ratio both for industry coauthorship with all universities and for industry coauthorship with Japanese universities alone. Figure 5 shows the total Japanese coauthorship ratio and the domestic Japanese coauthorship ratio along with the total American coauthorship ratio.

The two ratios for Japan are remarkably close, the only difference being that the domestic ratio is slightly lower (which by definition must be the case, since the ratio's numerator has been reduced from all coauthored articles to only those coauthored with Japanese universities, while the denominator of all industry articles is the same for both ratios). It is clear from even this overly stringent criterion that neither the strength nor the growth of the university-industry linkage in Japan as measured by coauthorship is a result of reliance on foreign universities.

Figure 5. Coauthorship ratios in Japan (all and domestic universities) and the United States



According to the empirical evidence, Japan does not appear to be overly dependent on foreign universities, nor is the growth in Japan's linkage to foreign universities being driven by relations with American universities. Hicks suggests one reason why the perception of that Japanese industry is overly dependent on American public research is so widespread (Hicks 1993 pp. 389-390):

> One difference between the types of research links that Japanese and Western companies initiate may be the substantial role of secondments in Japan, visible especially in the formal programs under which employees are sent to foreign universities. If Western companies do not second researchers to Japanese universities on such a regular basis, this would contribute to the perception that the Japanese extract much more from Western systems than does the West from the Japanese.

The coauthorship metric is just a single measure, and it alone cannot fully describe the university-industry linkage. It is sufficient for our purposes, however, that the metric provides strong empirical evidence that the conventional wisdom and its assumption of a university-industry disconnect in Japan are on faulty ground. Moreover, the lesson of this choice of measurement metric is that it supports a robust analysis through its policy framework neutrality and its direct measure of the incidence of collaboration. Such critical analysis is essential as a foundation for policy reform.

5. CONCLUSION

By relying on assumptions and conventional wisdom about the Japanese innovation system, reformers of the university-industry linkage policy framework in Japan may be heading down blind alleys and making wrong turns. Clearly, the evidence which has been claimed to indicate a weak university-industry linkage in Japan (e.g., lower university patenting, lower university-industry inter-sector R&D funding flow) are the results of the choice of policy framework in Japan. Therefore, the first place to for reformers to start is to re-evaluate policy objectives in Japan.

Following the end of the long-term growth period and the need to re-adapt to current and future markets, it would not be surprising if the values that led to the public model for the Japanese university sector have evolved to support a suboptimal type of policy framework. If so, radical changes may be called for. These changes will not be forthcoming, however, if Japanese policy-makers skirt a comprehensive re-evaluation and fall back on claims that the university-industry linkage is dysfunctional based on simplistic analysis.

Putting aside the issue of whether the Japanese linkage is efficient or not (which it may not be by current definitions of efficiency), the existence of links means that a discourse built around the creation of university-industry linkages where none existed before is off the mark. This in turn casts doubt on whether critical accounting for the costs and benefits of new policy options are really being taken into consideration. In fact, there is every reason to believe that the shortcoming of the university-industry linkage in Japan is not lack of links, but lack of flexibility in the linkage. With the faster cycle times and the marginal advantage that innovation-based competition is spurring today, the ability to leverage external resources and create inter-organizational synergies is critical. A system that enables agile relationships—both in the creation and disbanding of links—has tremendous advantage. In fact, the rapid re-allocation of resources and institutional malleability of an agile American innovation system may be responsible for early adoption of information technology (IT). Recent research indicates that high IT utilization is behind much of American productivity gains over the 1990s (The Economist 2000, Oliner and Sichel 2000).

On the contrary, however, the reform discourse in Japan overlooks this potential growth source by relying on conventional wisdom. As a result, the direction of the current Japanese policy reforms is in some ways more complicated than ever, in many cases based on manipulating rather than replacing institutional obstacles. The result is haphazard, as witnessed by the schizophrenic nature of current policy reforms. Technology licensing organizations (TLOs) were allowed into the university system, but required the use of off-campus addresses, with graduate students serving as proxy officers in place of university faculty actually pulling the strings from behind. Consulting has been permitted but under

condition that it occur after-hours, a convenient bureaucratic cover. Private sector support of university research is encouraged through specific government programs, but even government foundations set up for the purpose of funding university research find it easier to send monies abroad and have them re-routed back to the Japanese university via the private bank accounts of university personnel than to fund Japanese universities directly.[9] Rather than making the university-industry linkage more fluid, the reforms may sustain the high transaction costs of relational flexibility in Japan. If so, they will likely preserve the status quo in terms of which organizations and individuals interact with each other.

A key lesson of this research is that mutual learning in the policy reform process must take into account the particular characteristics of distinct institutional environments. Hand-in-hand with this country-specific approach, however, it is also important to consider when and where underlying trends common across the distinct systems may be driving change. For instance, one explanation for the strong Japanese linkage measurement evident in this research in spite of conventional wisdom to the contrary is that a universal trend in the relationship between public science and industrial innovation may be driving change in the linkage in all countries. For example, Mansfield demonstrated this change across the last three decades for the drugs and medical products, information processing, chemical, electrical, instruments, metals, oil, and machinery industries (Mansfield 1998 p. 775):

> ... over 10% of the new products and processes introduced in these industries could not have been developed (without substantial delay) in the absence of recent academic research.

He further concluded (Mansfield 1998 p. 776):

> ... there was a decrease in the average lag between academic research results and the first commercial introduction of new products and processes based on these results.

In another seminal study, Narin et al. studied 430,226 front-page references on 397,660 U.S. patents issued in 1987-1988 and 1993-1994. They revealed an increase in the linkage of technologies to public science, concluding (Narin et al. 1997 p. 330):

> The underlying hypothesis described in the beginning of this paper—that public science is a driving force behind high technology—is clearly supported by the data shown herein.

Although it is true that both of these studies examined the United States, there is reason to expect these findings to be relevant to Japan as well. For instance, although the Narin et al. study was of patents in the United States, even these patents demonstrated a substantial linkage to foreign as well as American public science (Narin et al. 1997 p. 317):

> A strong national component of this citation linkage was found, with each country's inventors preferentially citing papers authored in their own country, by a factor of between two and four.

Japanese patents were on the high end of citing own-country research sources.

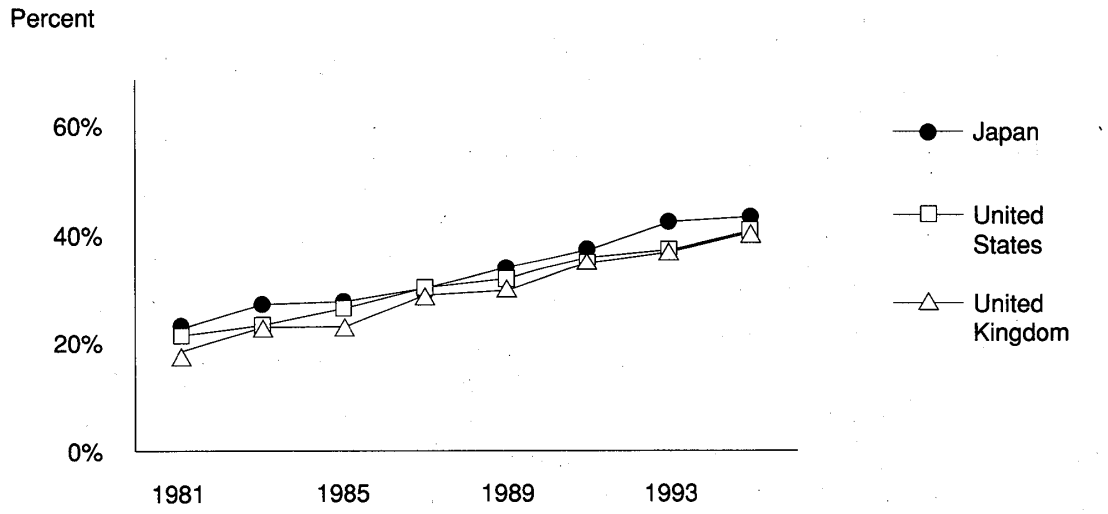
If the Japan university-industry linkage is not necessarily dysfunctional, we would expect there to be direct evidence indicating that Japanese industry is interested in Japan university research. We find such evidence in the comparative United States-Japan survey by the

9) Author's experience.

Japanese National Institute of Science and Technology Policy. Based on a survey of over 1400 firms in Japan and the United States, the survey concluded that as a source of R&D information, Japanese firms relied more on Japanese universities than American firms relied on American universities and public research institutes combined (Goto & Nagata 1997 pp. 33-35), and as a source of technological information American firms relied on American universities only two-thirds as often as Japanese firms relied Japanese universities (Goto & Nagata 1997 pp. 53-54). This certainly lends support to the idea that the Japanese industry sector does indeed find the Japanese university sector to be a relevant source of knowledge.

The hypothesis of a common basis for linkage growth is supported by the study of coauthorship linkages in the United Kingdom by Hicks and Katz (Hicks and Katz 1997). Figure 6 shows the U.S.-Japan comparison of Figure 3 with the trend from Hicks and Katz superimposed (ibid. p. 136).

Figure 6. Coauthorship ratios in the United Kingdom, the United States and Japan



The remarkable similarity between these three countries' university-industry linkages as measured by coauthorship supports the notion that something universal may be underlying university-industry linkage trends. If a universal driver of change is indeed the case, observing this trend depends on viewing it through a policy-neutral lens rather than one of country-specific biases.

As managers, academicians, and policy-makers in Japan tackle the difficult questions of how to support economic growth, it is only natural that they look to the American economy for answers. American industry managed not only to recover from its ailments of the 1980s, but has done so by capitalizing on its innovative capabilities to usher in the new economy. The renewed strength of existing firms together with the vibrant birth of new firms in the information, biotechnology and service industries reveal to Japanese leaders a potential path to economic expansion.

However, while the emerging practices in the United States are indicative of trends

affecting innovation worldwide, they are also products of the specific characteristics of the American innovation system. The Japanese innovation system, which evolved along quite a different development trajectory, must now make the transition to practices fitting for the new economy. Policies are needed which promote an innovation system amenable not only to the creation of new knowledge, but to the identification of new markets and to the bridging of the gap between ideas and real products. Embedded linkages and transnational interactions are likely to play key roles in this kind of innovation system, thus continuing the challenge to and importance of critical assessment in support of policy reform.

Nathan Rosenberg described the American experience with the role of universities in the innovation system this way (Rosenberg 2000 p. 14):

> Looking backward, what seems to have evolved in the U.S. in the past half century is a new set of networks and institutional modifications that compensate for some of the more obvious limitations to the research capabilities of small, startup firms. In particular, the symbiotic relationship that now exists between university research and spillovers into the world of industrial innovations is a powerful determinant of economic performance in the American economy.

But Rosenberg also cautioned (ibid.):

> Much additional research is necessary in order to probe more deeply into the exact nature, and extent, of the interdependence of the various components of these networks, and how they might be further strengthened. And, of course, it needs to be asked what lessons can be drawn from the American experience, and which of these separate components, or modifications of these components, might be usefully transferred elsewhere.

It is precisely for such reasons as this that critical analysis is a prerequisite for policy reform, and this depends in turn on separating empirical facts from conventional fictions.

APPENDIX A: ORIGINAL INTER-SECTOR R&D COMPARISON METHODOLOGY

Original comparison methodology (see Pechter 2001 UT for adjustment factors and other details):

1. Use National Science Board 2000 for the United States and Management and Coordination Agency 1996 for Japan.
2. Use science and engineering R&D only.
3. For both industry and university R&D use the union of R&D expenditure and performance including payments to and from abroad (for NSF, NISTEP, and OECD, industry R&D uses industry R&D expenditure only and university R&D uses R&D performance only).
4. Use Management and Coordination Agency 1996 for Japan payments to foreign organizations and National Science Board 2000 for United States payments to foreign organizations.
5. Include university-managed government-funded institutes in university sector.
6. Adjust Japanese data by the estimates of full-time equivalence factors (divide Japanese university R&D by 1.3 and Japanese industry R&D by 1.2).
7. Adjust American university R&D to include non-separately budgeted R&D (multiply American. university R&D by 1.3).
8. The resulting adjusted data allows an improved but by no means optimal comparison of the United States and Japan.

APPENDIX B: COAUTHORSHIP ANALYSIS METHODOLOGY

Analysis utilized a bibliometric database from the Institute of Scientific Information (ISI) in the United States and maintained by the National Center for Science Information Systems (NACSIS) in Japan. The database contains the set of data for the years 1981-1996 in which at least one affiliation of an article's authors is to an organization in Japan. The set contains approximately 800,000 records. Analysis then identified a subset out of these 800,000 articles according to three criteria:

- articles with at least one Japanese industrial affiliation,
- articles categorized as articles, notes or proceedings articles (no reviews, letters, etc.),
- articles from the journals of all fields other than economics and business, education, law, psychology/psychiatry, and social sciences-general.

The study set thus obtained contains 110,588 articles.

In order to determine the industrial sectors of firms, analysis referred firm-by-firm to the *Company Quarterly Handbook* (Toyo Keizai Shinposha 2000) and the *Nationwide List of Research Institutes* (Science and Technology Agency 1997-1998).

Analysis determined author affiliation to either industry, academia or elsewhere by searching the author affiliation data field by for the following key words:

- Academia: UNIV, COLL, SCH, ACAD, and INST (INST records were verified manually).
- Industry: CO, LIMITED, LTD, INC or KK (Japanese term corresponding to INC).
- Authors not belonging to the above categories were designated as "other." This primarily includes national laboratories, public corporations, and non-university hospitals.

This methodology enables empirical analysis of the incidence of university-industry interaction in the research process, doing so from the perspective of industry.

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