Colloquium:

Comparative Policy Analysis Under Innovation-Driven Change:

Assessment of the University-Industry Linkage in Japan and the United States

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Abstract

This paper is the third in a series addressing Japanese university-industry linkage policy reforms. The first paper analyzed the linkage using bibliometric techniques, demonstrating links to be prevalent and growing. The finding opposes the widespread belief that Japanese industry and universities have little research interaction, a major justification for reforms. The second paper presented empirical support for this finding, demonstrating the linkage to be substantive. The current paper reconciles the finding of a strong university-industry linkage in Japan with the taken-for-granted assumption of weakness in the linkage, by considering the process of comparative innovation system assessment in the context of innovation-driven change.

I. INTRODUCTION

Variety in innovation policy and management throughout the world creates both opportunities and challenges in this age of global interdependence. In attempting to support the unmanageable task of managing innovation, policy-makers utilize the lessons of other nations' approaches to inform their own approaches. As intensifying competition and the emergence of info- and biotechnologies rapidly transform the research and business landscapes throughout the globe, this is all the more so. Sometimes, however, ill-informed assessments of other nations' approaches muddy rather than clarify these turbulent waters. The reformulation of university-industry linkage policies in Japan is one such case. By not distinguishing between disparate effects of distinct policy frameworks on the one hand and innovation as a common driver of performance on the other hand, analysts risk treating inputs (policy
frameworks) as outputs (performance measures) and thus turn to ill-conceived justifications for policy reformulation.

This paper is the third in a series presented at IEEE Engineering Management Society conferences addressing Japanese innovation policy reforms of the university-industry linkage. The first paper [#1] analyzed the university-industry linkage in Japan using bibliometric techniques and showed links to be prevalent and growing. The finding opposes the widespread belief that Japanese industry and universities have little research interaction, a major justification for ongoing reforms. The second paper [#2] presented further empirical support for the finding, demonstrating that the coauthorship linkage is substantive in nature (e.g., comparable to the U.S., not the result of dependence on foreign universities, and not a peculiarity such Japanese conditions as the bubble economy of the 1980s and 1990s and Japan's dissertation doctorate system).

The present paper reconciles the finding of a strong university-industry linkage in Japan with the taken-for-granted view of weakness in the linkage, by considering the process of comparative assessment of national innovation systems in the context of innovation-driven change. Specifically, by considering the metrics used in conventional comparative assessments of university-industry linkages (e.g., university patents and R&D cross-sector funding) in the contexts of the different policy frameworks in the United States and Japan, the paper demonstrates the utility of a policy framework-independent metric such as university-industry coauthorship in the face of innovation as a common driver of change.

II. THE CHALLENGE OF COMPARATIVELY ASSESSING INNOVATION SYSTEMS

A. PAST EXPERIENCE
Like the practice of innovation itself, the formulation of policies in support of a vibrant and competitive innovation-based economy is more art than science. With no way to calculate an optimal approach, policy-makers, like managers in the companies their policies support and regulate, must rely on trial-and-error in their craft. Fortunately, the variety of approaches to innovation policy throughout the world means that each country does not have to endure each trial itself. By learning through the experiences of other countries, policy-makers may develop understanding about other approaches without having to implement them themselves. In this sense, variety in approaches creates opportunities for mutual learning between countries.

However, policy-making differs from management in a crucial aspect: while
business activities transcend borders, particularly in the firms and industries that 
drive much of the change in today's economies, policies are by nature directed at 
regions defined by borders. Perhaps the greatest challenge posed by the 
nationalistic nature of policy-making is that policy-makers often misunderstand 
the nature of the policy frameworks of other countries. This lack of understanding 
leads them to misinterpret the rationale of other countries' policies and 
incorrectly assess their outcomes.

Due to the juxtaposition of today's strong American and weak Japanese 
economies, most of the learning between the United States and Japan seems to 
go in one direction. It was, however, not too long ago that Americans were 
looking to Japan for answers. It was believed that the particular nature of the 
Japanese economic system gave advantages to Japanese firms, and perhaps 
American policy-makers needed to adjust American policies accordingly in order 
to reap similar benefits. For instance, Japanese firms were seen as being very 
cooperative in their activities. Visible examples of this were Japanese research 
consortia. For years Japanese research consortia were labeled as collusive and 
anti-competitive, and worse, not rational from the economic point of view. 
Explanations for such irrational behavior were found in cultural inclinations toward 
harmony, the Japanese experience of having to live together in cramped quarters, 
and Japan's feudalistic heritage. American observers saw cooperative research 
consortia in particular as key to innovation in Japan and thought that American 
policies should be changed to allow more cooperation among U.S. firms. This led 
to the 1984 Cooperative Research Act, which provides a certain level of anti-trust 
protection for inter-firm cooperation in research and development [#3]. The idea 
was that if Japanese firms could cooperate for the purpose of improving Japan's 
competitiveness in advanced industries, so could the United States. In order to 
comply with economic rationality, the U.S. consortia would be based on 
early-stage or precompetitive research where firms were more likely to 
cooperate.

The trouble with the new American policy was that it was based on incorrect 
assumptions: the notion that Japanese consortia were based on inter-firm 
cooperation was wrong. As Gerald Hane (formerly of the White House Office of 
Science and Technology Policy) showed, the companies involved in Japanese 
consortia "did not focus on precompetitive research, rarely worked together at 
centralized locations, did not attempt revolutionary advances, and did not directly 
share information among competitors" [#4]. The consortia were instead 
organized in order to leverage competition between firms, in a manner Hane 
termed "procompetitive coordination." The University of Tokyo's Fumio Kodama, 
who has investigated Japanese research consortia extensively, determined that 
the goal of consortia was not to make major breakthroughs in the industries of 
participant firms, but rather to collectively articulate the demand of these firms 
for equipment and instrumentation [#5]. Through this process, which he has
termed "demand articulation," Kodama showed how the consortia led second tier firms to produce the machinery that resulted in Japanese dominance in such areas as semiconductor devices. Both Kodama and Hane demonstrated quite rational explanations for what had previously led American policy-makers to conclude was irrational behavior in Japan.

As can be expected, such gross misunderstandings contributed to a worsening of U.S.-Japan relations, which was only alleviated by the eventual collapse of Japan's bubble economy and subsequent prolonged recession. At the time, an attempt to improve these relations was made through a series of dialogues at the quasi-governmental level [6]. The dialogues were carried out throughout the 1980s and 1990s under the auspices of the Committee on Japan of the U.S. National Research Council (the operating arm of the U.S. National Academies of Sciences and Engineering), and the Committee on Advanced Technology and the International Environment under the auspices of the Japan Society for the Promotion of Science (known by its chronological order among the university-industry cooperative research committees formed by the JSPS since 1933, Committee 149). While the dialogues did much to improve mutual understanding and communication both between the two countries and within their respective policy communities, not even the capable members of these committees were able to find common ground between American and Japanese approaches.

One specific example, with direct implications to the current university-industry linkage reform process, occurred early in the dialogues: the debate over the issue of asymmetric access. The debate was founded on the belief that Japanese firms had access to the base of American leading-edge researched located in the open environment of U.S. universities, while Japan's leading research was located behind the closed doors of private industry and thus was out of reach to American industry [7]. According to this view, access to Japanese universities for American firms meant little, since even Japanese firms did not draw much from Japanese universities other than a well-filtered supply of new employees.

We see, therefore, that the assumption of a disconnection between university research and industrial innovation in Japan has been driving debate for a long time. The word assumption is used here not because this paper insists that the university-industry linkage in Japan necessarily exhibits strong economic performance, but because the opposite position - that the university system has been irrelevant - has been taken as a given without an adequate empirical basis. For this reason, it is crucial to start with a clean slate and critically assess the university-industry linkage in Japan.

B. CURRENT CONTEXT

The framework that regulates how university personnel interact with industry in
Japan has been based on a public model. In such a model university investments in research, particularly those of national and public universities, are intended to deliver benefits to the social welfare 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 socially beneficial areas which 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 result of this public approach has been an arm's 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 firms, accepting employment in the private sector, and selling university-generated intellectual property. The government has severely restricted the type of university research that firms may fund and has prohibited firms from hiring university personnel as consultants. The Ministry of Education, Culture, Sports, Science, and Technology (MOE) has not engaged in profit-seeking activities with university resources, and has guarded its turf from the overt influence of industry by restricting funding of university personnel by industry and other ministries, specifically the former Ministry of International Trade and Industry (MITI), as of 2001 now known as the Ministry of Economy, Trade and Industry (METI).

How is the situation changing? Here are a few indications of the direction of change. An Office for Promotion of Academia-Industry Cooperation was established in the former MITI's Industrial Policy Bureau. CASTI, a corporation founded with personal funds by individual University of Tokyo professors for the purpose of selling the results of faculty-conducted research to industry, is being operated on the campus of the university's Research Center for Advanced Science and Technology. MOE and MITI jointly drafted legislation to make this possible, and there are at least 15 other such organizations affiliated with Japanese universities. One of the more recent members of Sony's board of directors, Iwao Nakatani, came not from industry but from a national university. Although he eventually had to resign his professorship in order to join the board, then Prime Minister Keizo Obuchi asked the National Personnel Authority to consider allowing such activities by national university personnel. Private industry funding of university research is being encouraged, and organizations such as the Japan Science and Technology Corporation are working with universities to encourage the development of promising university research into marketable products. For more detail see [8].

Although this striking consensus has been reached - or precisely because it has - it is important to consider critically the assessments that have led to it.
III. COMPARATIVE ASSESSMENT OF THE UNIVERSITY-INDUSTRY LINKAGE

A. THE JUSTIFICATION FOR REFORM

A rather simplistic argument has emerged as the standard rationale for the 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, firms spun-off 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 U.S.

The former director of MITI's Office for Promotion of Academia-Industry Cooperation provides an example of the standard rationale in MITI's own Journal of Japanese Trade & Industry in an article titled "Desirable Form of Academia-Industry Cooperation" [#9]. Note also that this argument is identical in form to other dominant perspectives, such as that made by Japan's Federation of Economic Organizations or Keidanren in the form of an urgent policy statement [#10]. 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, and also compares firm formation from U.S. and Japanese universities. Another line of argument concerns the comparison of the flow of R&D funding from the private sector to universities. This argument has appeared in such prominent recent examples as a volume by leading Japanese researchers on Japanese university policy reform [#11] and in the keynote address to the March 2001 meeting of the Japan Association for Evolutionary Economics [#12]. These arguments are depicted in tabular form in Table 1 and Table 2.

<table>
<thead>
<tr>
<th>Sector</th>
<th>R&amp;D</th>
<th>Researchers</th>
<th>Patents</th>
</tr>
</thead>
<tbody>
<tr>
<td>University</td>
<td>20%</td>
<td>35%</td>
<td>0.04%</td>
</tr>
<tr>
<td>Others</td>
<td>80%</td>
<td>65%</td>
<td>99.96%</td>
</tr>
</tbody>
</table>

Source:[#9]

<table>
<thead>
<tr>
<th>Metric</th>
<th>Japan</th>
<th>U.S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industry-to-University R&amp;D Funding Flow</td>
<td>72 bil yen</td>
<td>346 bil yen</td>
</tr>
</tbody>
</table>
University-held Patents  | 129 patents | 1,862 patents
Royalties from Patents  | 0.03 bil yen | 57 bil yen

Source: [#9, #12, #13]

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. According to this definition 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.

While this argument for change has tremendous appeal in today's sluggish Japanese economy, it is logically flawed. This flaw obfuscates the true need for reformulation and in so doing diverts the process from potential solutions. To understand why this is so, we must consider differences in the university-industry policy frameworks in the United States and Japan.

**B. PROBLEMS WITH THE JUSTIFICATION**

It is no exaggeration to say that the university-industry linkage in the U.S. is undergoing a revolution. The American framework was formerly based on a model much closer to a public model. Starting in the late 1970s, however, legislation 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 framework. For the first time, the new laws granted intellectual property rights from federally funded research to universities, with stipulations to ensure profit sharing with faculty inventors. The move was in part a response to beliefs that little federally funded research was ever commercialized [#14]. Considering that federal obligations for university science and engineering research alone in the 1970s (not including fellowships, traineeships, instructional facilities, or R&D plants) averaged over $2 billion per year [#15], the public approach for generating social returns appeared inefficient. The new framework aimed to improve the economic contribution of academic research in two steps. Through the incentive of profiting financially from their research, university researchers would turn their attention to economically useful inventions. By allowing universities to receive licensing royalties, university administrators had the incentive to actively market faculty-created inventions. These policy adjustments were catalysts for change as universities, responding to science developments, increasingly ventured into market-oriented approaches. These approaches include not only patenting, but also faculty consulting, venture capital utilization, and firm formation. What is truly revolutionary about this change is that while personal financial gain was once an anathema, today's
university researchers are increasingly compelled to demonstrate a positive bottom line in their research portfolios.

What this means to the standard rationale is two-fold. First, since the American framework has been market-oriented for years while the Japanese framework has been based on a public model, we expect that American universities will hold more patents than will Japanese universities. As such, 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 a good thing. The same thing can be said about such other market-oriented adaptations as faculty consulting and spin-off firms. The second implication is that again, 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.

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.

IV. THE NEED FOR EMPIRICAL ASSESSMENT

A. ASSESSING POLICY ALTERNATIVES

Since this paper is concerned foremost with assessing the university-industry linkage in Japan, it will not comprehensively deal with the American policy framework. Nonetheless, because this assessment is crucial to the direction of reform Japan is embarking upon, it is valuable to at least touch on it. Is a market-oriented university-industry policy framework like that in the United States good for Japan? Although surprisingly little empirical analysis has been done on this issue, one such analysis was a University of Tokyo-Harvard University joint study [#16]. In a seminal chapter from the book which encapsulates the study's findings [#7], Mowery et al. demonstrate empirically that much of the rise in academic patenting 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 [#17]. 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. While the answer to this question will likely vary depending on the location and the 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.

**B. ASSESSING CURRENT POLICIES**

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 policy frameworks (such as university-held patents and industry-to-university R&D funding flow) are not accurate metrics of linkage performance. Why then, we are compelled to ask, have they taken such a dominant position in the ongoing reform discourse? While a complete answer is beyond the scope of this paper, a major reason is the preconceived perception of weakness in the Japanese university system. Accordingly, 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.

1) 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. Patents, the granting of a limited monopoly for the sake of encouraging the investment needed to develop an idea into a product, are 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 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 in trade associations and industry groups, participation in deliberative committees, membership in study groups (the ubiquitous Japanese kenkyuu-kai), 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 paper'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 paper 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 [#18]. 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 [#19]:

... 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.

2) Industry-to-University R&D Funding Flow
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 different 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. 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 [#20], while "university R&D statistics are notoriously difficult to compile and may be seriously flawed" [#21].

In order to gauge funding flow differences, we 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 the U.S. National Science Foundation (NSF), the Japanese National Institute of Science and Technology Policy (NISTEP), and the Organization for Economic Cooperation and Development (OECD). Table 3 shows the official comparisons.
In addition, an original comparison has been added based on adjustments to make the two countries’ data even more comparable (see the appendix 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. Thus, 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.

Table 3. Industry-to-University R&D Funding Flow as a Percentage of Industry and University R&D (1996)

<table>
<thead>
<tr>
<th>Industry</th>
<th>Japan</th>
<th>U.S.</th>
<th>Japan/U.S. Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSF</td>
<td>0.5%</td>
<td>1.5%</td>
<td>0.3</td>
</tr>
<tr>
<td>NISTEP</td>
<td>0.7%*</td>
<td>1.4%</td>
<td>0.5</td>
</tr>
<tr>
<td>OECD</td>
<td>0.7%*</td>
<td>1.4%</td>
<td>0.5</td>
</tr>
<tr>
<td>Original</td>
<td>0.7%</td>
<td>1.0%</td>
<td>0.7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>University</th>
<th>Japan</th>
<th>U.S.</th>
<th>Japan/U.S. Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSF</td>
<td>2.3%</td>
<td>7.0%</td>
<td>0.3</td>
</tr>
<tr>
<td>NISTEP</td>
<td>2.3%*</td>
<td>5.8%</td>
<td>0.4</td>
</tr>
<tr>
<td>OECD</td>
<td>2.4%*</td>
<td>5.8%</td>
<td>0.4</td>
</tr>
<tr>
<td>Original</td>
<td>4.0%</td>
<td>4.4%</td>
<td>0.9</td>
</tr>
</tbody>
</table>

*Japanese data from NISTEP and OECD are for 1995
Source: [for NSF #22, for NISTEP #23, for OECD #24]

V. ROBUST ASSESSMENT UNDER CHANGE

We have seen that conventional assessments of the university-industry linkage in Japan have incorrectly been assumed to indicate weakness. How is it that a linkage so long assumed to be dysfunctional might in fact be quite functional. One explanation a universal trend in the relationship between public science and industrial innovation driving change throughout the world. For example, Mansfield showed this across the last three decades for the drugs and medical products, information processing, chemical, electrical, instruments, metals, oil, and machinery industries [#25]:

... 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 concludes [#26]:

... 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.


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 U.S. patents, even these patents demonstrated a substantial linkage to foreign as well as American public science [#28]:

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 such citations.

If, as the present paper asserts, 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 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 [#29], and as a source of technological information American firms relied on American universities only two-thirds as often as Japanese firms relied Japanese universities [#30]. 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.

In order to compare the university-industry linkages in the U.S. and Japan, we need a metric that is policy-neutral and directly measures the linkage. Here we arrive at the basis for the coauthorship analysis of the previous two papers in this series of research [#1, #2]. By compiling data on the scholarly coauthorship patterns between Japanese industry and university researchers, the papers demonstrated that the university-industry linkage has been consistently strong. In 1981, over 20% of all industry papers were coauthored with an academic researcher. That percentage doubled in following fifteen years so that now more industry papers are published with an academic coauthor than
with members of the same firm. Furthermore, this research showed that the coauthorship figures are nearly identical to figures for the United States (for further detail, see [31]).

While coauthorship measures only a particular mode of the university-industry linkage, it is a superior comparative linkage indicator than the patent and spin-off firm counts so often cited in the standard rationale. Although further research certainly is necessary, one conclusion of the coauthorship data is that whatever is driving the change in the American system, it has already been producing similar effects in Japan independent of the current actions of policy-makers.

VI. CONCLUSION

Because policies that regulate innovation are inherently national while business activity is increasingly global, differing approaches to innovation are bound to present challenges as well as opportunities to policy-makers. The world is a living laboratory, where different approaches can be experimented with and the outcomes of these approaches assessed. The benefits of variety are limited, however, by the accuracy of these assessments. In order for mutual learning to occur, systems must be analyzed empirically to generate understanding. This analysis must be sensitive to innovation as a driver of change beyond the bounds of national policies.

APPENDIX

Original comparison methodology:


2. Uses science and engineering R&D only.

3. Both industry and university R&D uses 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).


5. University-managed government-funded institutes included in university sector.


7. American university R&D adjusted to include non-separately budgeted
8. The resulting adjusted data allows an improved but by no means optimal comparison of the U.S. and Japan.

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[26] Ibid. p. 776.
[28] Ibid. p. 317.

Source: Global Communications Platform from Japan  [http://www.glocom.org/](http://www.glocom.org/)