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1.1.2 Knowledge transfer mechanisms from universities

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Abstract

In addition to the traditional, fundamental mission of education and academic research, universities are required to tackle more direct contributions to society in what might be termed their "third mission." This paper discusses the transfer of knowledge from universities to industry through industry-academia collaboration, including the classification of research projects by purpose, the contribution made by academic research to innovation, and an assessment of the impact of the Bayh-Dole Act in the United States.

Keywords

Industry-university collaboration, intellectual property rights, TLO, University Intellectual Property Office, Pasteur's Quadrant, innovation based on academic research, Bayh-Dole Act

1 Introduction

In respect to the research activities carried out by universities, which comprise the "academic" sector, it is undeniable that the results of research that can be applied to industry should be made available for use in the industry sector. Universities do not manufacture finished products. Therefore, in order to utilize research results in the industrial sector and return them to society, it is essential to transfer the knowledge generated at universities to industry through "industry-university collaboration" and link it to the creation of new products, services, and processes (i.e., product innovation and process innovation). Universities can also

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acquire useful knowledge for their research activities by obtaining technological knowledge accumulated in companies and by understanding the needs for new product development.

The main forms of knowledge transfer between industry and academia include the “technology transfer” approach, in which the results of research conducted at a university are transferred to a specific company or institution; the “joint research/contract research” approach, in which the needs of a specific company are taken into account when conducting research and development at a university from research theme-setting stage; and the “university venture” approach, in which a startup company is established based on the results of research conducted at a university and develops this research further.

Knowledge transfer between industry and academia is also achieved when multiple institutions in industry, government, and academia form a research and development consortium[2] or when technical guidance and advice are provided through formal or informal activities between researchers belonging to different sectors. University knowledge is also transferred to companies by employing students, graduate students, and postdoctoral fellows with expertise in specific fields, while industry knowledge is transferred to universities by having industry personnel give lectures and provide research guidance.

Regardless of which form of industry-academia collaboration is used—be it technology transfer, joint research/contract research, or university-launched startup as described above—private companies place particular importance on whether they can have exclusive use of an invention when they conduct development research aiming for commercialization using an invention created at a university. This is an important factor in determining whether or not the company in question will invest in development research. This is because even if development is successful, if other companies develop the same product, they may not be able to control market share and the investment may be wasted. For this exclusive use to be possible, the invention created within a university must, as a precondition, be granted rights in the form of a patent. Therefore, the acquisition of intellectual property rights, including patent rights, and the activities of human resources able to lead these activities[3] are important factors when considering the success of industry-university collaboration.

2 Relevant policies in Japan[4]

Following the enactment of the Basic Act on Science and Technology in November 1995, and the cabinet decision on the First Science and Technology Basic Plan in July 1996, measures relating to industry-university collaboration were pursued in the latter half of the 1990s. Such measures were implemented in response to the growing expectations of universities as a source of technological innovation by which to achieve economic revitalization and the growing need to give back to society by increasing university research funding amid the economic downturn at the time.

2 For an explanation of R&D consortia, see, for example, National Center for Industrial Property Information and Training (2010).

3 Its history is summarized in Takahashi Makiko, Furusawa Yoko, Edamura Kazuma and Sumikura Koichi (2018).

4 The description in this section is based on Sumikura Koichi (2003), with some additions and corrections.

In 1998, technology licensing organizations (hereinafter, TLOs; while they are often called OTLs in the US, this paper exclusively uses TLO to refer to US technology licensing organizations) appeared in Japan as a symbol of patenting university inventions. In the same year, the Act on the Promotion of Technology Transfer from Universities to Private Business Operators set forth the conditions for obtaining government approval as an "approved TLO." The first four TLO institutions were approved under the Act that year.

Patent application procedures and the licensing of patent rights can also be conducted by the inventory, that is, the university faculty member themselves. However, as most faculty members do not have such know-how, there is a need for an organization that can decide whether to apply for a patent, file a patent application, and grant a license on behalf of faculty members. TLOs are responsible for this. As the name suggests, the main function of TLOs is the "transfer of technology" from universities to private companies.

Typical TLO activities include receiving reports from university laboratories, identifying inventions, deciding whether to apply for a patent on the invention, filing a patent application in cooperation with an outside patent office or other organization, selling the patent-pending invention to a specific company, and concluding license agreements. Once a TLO deducts actual costs and administrative expenses, a certain share of the license income obtained is returned to universities, faculties, inventors' laboratories, and individual inventors. After ascertaining which companies want what kind of technology, the technology transfers professional staff at TLOs make a business proposal based on the new technology. In this way, the function of TLOs is essentially the transfer of university knowledge to the industry sector—that is, the transfer of technology from academia to industry. However, depending on the organization, TLOs may play a substantial role in introducing university researchers able to meet a company's needs or in supporting the establishment of university-launched startups.

In 1999, Article 30 of the Act on Special Measures for Industrial Revitalization established what could be called the Japanese version of the Bayh-Dole Act, which states that where a contractor meets certain conditions, 100 percent of intellectual property rights pertaining to all outsourced research and development conducted by government-funded ministries and agencies can be attributed to the contractor. These certain conditions are as follows: (i) report to the state on the results of the research, if any; (ii) license those intellectual property rights to the state free of charge, where the state has need in the public interest; and (iii) license such intellectual property rights to a third party at the request of the state if those intellectual property rights have not been exercised for a reasonable period of time. However, at this point in time, national universities did not have corporate status and were thus not subject to this provision. Therefore, for inventions born at national universities, the right to receive a patent was attributed to either the individual or the national government, with the decision of which of the two decided by the Invention Committee of a university. The system did not allow universities as institutions to become patent owners and manage them. The Japanese version of the Bayh-Dole Act was later transferred to Article 19 of the Industrial Technology Enhancement Act in 2007.

The Outline of the Intellectual Property Strategy and the Intellectual Property Basic Act were enacted in 2002. Article 13 of the Act states that the government will promote "improving systems in universities, etc., to utilize human resources that have expert knowledge on intellectual property, improving proceedings pertaining to registration for establishment on intellectual property rights, carrying out research and study on market, etc., and providing market information." Established in March 2003 in response to the Basic Act, the government's Intellectual Property Strategy Headquarters announced the "Promotion Plan," discussed below, in the July of the same year.

In 2002, the Ministry of Education, Culture, Sports, Science and Technology's (MEXT) Intellectual Property Working Group reviewed the attribution of patent rights after the national universities were incorporated, and studied the ideal way to manage patents. Released in November 2002, the Report of Intellectual Property Working Group[5] stated that "universities, being ubiquitous in human society and social entities that live with the times, must position more direct contributions to society as their 'third mission', so to speak, in addition to their traditional basic missions of education and academic research, and tackle this head-on." The report also stated that, "in principle, rights related to intellectual property should be attributed to institutions." This was a precursor to the national university incorporation implemented about eighteen months later.

July 2003 was a historic turning point for Japan's national universities. On July 8, 2003, the government's Intellectual Property Strategy Headquarters released the Promotion Plan for the Creation, Protection and Exploitation of Intellectual Property. On the following day, July 9, the National University Corporation Bill was passed by a plenary session of the House of Councilors and enacted. On July 15, MEXT announced the forty-three organizations[6] selected for the University Intellectual Property Headquarters Development Program. Under the National University Corporation Act, each national university corporation has been able to independently own and manage intellectual property rights since their incorporation in April 2004. National university corporations were then required to set up organizations such as "university intellectual property headquarters" within universities to manage intellectual property.

3 Basic concepts and issues[7]

3.1 A modal theory of science and technology activities

As Kobayashi Shinichi (1999) notes, "Promoting industry-academia collaboration means fundamentally rethinking our view of science and technology, such as what constitutes science and technology activities, what the role of science and technology activities in society is, and what kind of relationship they should have with other institutions and organizations. This is a fundamental question that will lead to a review of the state of universities, the state of research activities across the country as a whole, and the state of science and technology policy."

5 Intellectual Property Working Group, Committee for the Promotion of Industry-Academia-Government Collaboration, Technology and Research Infrastructure Committee, Science and Technology Council, "Report of the Intellectual Property Working Group" (2002), p. 3.

6 Thirty-four projects were adopted as the University Intellectual Property Headquarters Development Project, incidental to which nine projects were adopted under the Support Program for Management and Utilization Functions for Distinctive Intellectual Property.

7 The descriptions in 3.3 and 3.5 of this section are based on parts of Sumikura Koichi and Saito Hiromi (2014) with additions and modifications.

According to Gibbons et al. (1994), there are two modes of scientific and technological activities: Mode 1, in which activities are conducted according to the logic of a particular discipline; and Mode 2, in which a problem is identified and research activities are conducted for that purpose. Shinichi Kobayashi (1999) points out that research activities used to be conducted relatively freely in the US, with little concern given to the utilization of the results. However, from the late 1970s, when the country shifted from the Cold War era to one of economic competition, the need to contribute to enhancing industrial competitiveness emerged. It was from this perspective that research funds came to be allocated, resulting in Mode 2 becoming the dominant mode of research activities.

In an interview with Yoshida (2016) after the decision to award the Nobel prize, Professor Yoshinori Osumi, who was awarded the Nobel Prize in Physiology or Medicine in 2016, expressed his concern regarding the current situation facing Japanese researchers, who are under pressure to produce research results that are useful for something. He noted how it can take long time—ten years or even a century—before the results of basic scientific research turn out to be useful for something. This is an important point, and a necessary reminder of the need to reaffirm the importance of Mode 1 research activities. This warning notwithstanding, the results of both Mode 1 and Mode 2 research activities may have the potential to be useful in some way. In such cases, it is desirable to take measures such as filing a patent application with a view to future use in society and business development. In many universities in Japan, researchers are required to submit an invention report to the Intellectual Property Division of their university when they create an invention. As such, by fostering the judgement capabilities of those in charge of evaluating and deliberating on the future potential of an invention upon receiving its invention report, the possibility of utilizing Mode 1 research results in society can be expected to increase.

3.2 Stokes classification

Of the natural sciences research projects at universities, some are basic research projects that do not have immediate or direct applications, while others are applied research projects that respond to social needs. Stokes (1997) classified the objectives of research projects into four quadrants on two axes: whether the project pursues an understanding of fundamental natural phenomena, and whether the project aims to solve a specific problem in the real world. Of these, "pure basic research," which pursues understanding of fundamental natural phenomena and does not aim to solve specific real world problems, is referred to as Bohr's quadrant. "Pure applied research," which does not pursue the understanding of fundamental natural phenomena but aims to solve specific problems in the real world, is called Edison's quadrant. Meanwhile, "purpose-guided basic research," which seeks to understand fundamental natural phenomena while aiming to solve specific problems in the real world, is known as Pasteur's quadrant.

Nagaoka et al., (2011) conducted a survey of inventors in Japan and the US to determine what percentage of research projects that produced highly cited papers fell into each category. In Japan, 45 percent of projects were Bohr, 15 percent were Pasteur, and 15 percent were Edison; in the US, 46 percent of projects were Bohr, 33 percent were Pasteur, and 11 percent were Edison. The proportion of Japanese Pasteur-type research projects, which are expected to make effective returns to society through industry-university collaboration, was found to be less than half of that in the US.

3.3 The impact of the Bayh-Dole Act in the US

Policies to promote industry-academia collaboration have been developed in Japan since the late 1990s. At this time, one "model" used was the US system, which had been promoting the patenting of university research since the 1980s. One legislative development involving technology transfer from universities in the US was the Bayh-Dole Act, which was enacted in 1980 to partially amend the US Patent Act. Until then, patent rights for inventions developed with government funds (equivalent to more than 70 percent of university research expenditure) in universities belonged to the government, and only non-exclusive licensing was allowed (Loise and Stevens, 2010). The Bayh-Dole Act made it possible for the patent rights to inventions resulting from government-funded research to be held by the institution that received the funding and conducted the research (i.e., a non-profit organization such as a university or a small business). The number of universities with TLOs for technology transfer grew rapidly—increasing from twenty-three before the enactment of the Bayh-Dole Act, to most major research institutions now possessing TLOs, with more than 200 TLOs in the US alone (Loise and Stevens, 2010).

There are varying opinions on the evaluation of the Bayh-Dole Act.[8] In terms of the impact of the Bayh-Dole Act, Roessner et al. (2009) note that between 1996 and 2007, products made under license from universities created 279,000 jobs and technology transfer from academic institutions contributed USD 187 billion to the US GDP. On the other hand, in order to examine the effects of the Bayh-Dole Act, Mowery et al. (2001) conducted an analysis focusing on three schools, the University of California, Stanford University, and Columbia University. From the results, they concluded that the Bayh-Dole Act is only one of several important factors behind the increase in patenting and licensing activity surrounding university inventions.

3.4 The valley of death and the Darwinian sea

There is a gap between basic research at universities and applied research and development by private companies, in which it is difficult to obtain private investment for the development of early-stage technology; this is known as the "valley of death." The "valley of death" takes its name from Death Valley—now a national park in California—and is used to refer to something that one cannot pass through easily. This "valley of death" is considered to include the stage in which additional experiments are carried out in addition to the basic research published in the paper in order to bring it to a state where companies can consider adopting it. At this stage of research, there is rarely much incentive for researchers in academic institutions to conduct research, as it is not only difficult to obtain funding but also difficult to publish.

8 Loise and Stevens (2010), Grimaldi et al. (2011), and Furuya Maho and Watanabe Toshiya (2014) also present various opinions on the Bayh-Dole method, citing several references in doing so.

However, there are cases where researchers from academic institutions have established startup companies spun off from universities to develop technologies at this stage. The government may be able to help overcome the valley of death by creating a program to subsidize joint research and development between universities and companies or a consortium of several institutions for research and development at this stage in the development of technology.

According to Loise and Stevens (2010), the term "valley of death" can be traced back to Fawcett (1985). Fawcett (1985) states that every project has a stage typically referred to as the "valley of death," and that the term is used in reference to the technical hurdles that must be overcome. However, in a subsequent paper by the Committee on Science (1998), a committee member, Vern Ehlers, uses the term "valley of death" to refer to the gap between government-funded basic research and privately-funded applied research and development, where funding is difficult to obtain.

Rather than moving through the barren lands of the "valley of death," Branscomb and Auerswald (2001) argue that the actual situation involves sailing in the rough waters of the "Darwinian sea" between basic research and business, where many new technological ideas and business plans compete for survival and to achieve business success. In other words, the "Darwinian sea" exists between invention and innovation. In Japan, some claim that once the valley of death is crossed, the next step is to cross the Darwinian sea in the course of development from basic research to innovation. However, this is not what is proposed in Branscomb and Auerswald (2001), with the Darwinian sea proposed as an alternative concept to the valley of death.[9]

3.5 The contribution of academic research to innovation

According to Cohen and Levinthal (1990), in order to enhance their ability to realize innovation, firms must develop absorptive capacity, that is, the ability to recognize and absorb the value of new external information and apply it commercially. When a company conducts basic research in-house, it will broaden that company's knowledge base and contributing to its absorptive capacity because it will help the company find, understand, and use new external knowledge to develop new technologies.

Within the knowledge that is external to companies, to what extent do the results of the basic research conducted by universities contribute to innovation by companies? Various approaches have been used in attempts to provide a clear evidence-based answer to this question. In a a per-state analysis of time series data on corporate patent applications, R&D expenditures, and university research expenditures, Jaffe (1989) found a positive correlation between university research expenditures and corporate patent applications. The results of Mansfield's (1991) and Mansfield's (1998) company surveys suggest that without the results of academic research, 13–15 percent of new products would not have been developed or would have been significantly delayed in their emergence. Narin et al. (1997) showed that 73 percent of the academic papers

9 Kodama Fumio described this misunderstanding in Japan in his speech at RIETI on February 1, 2005, "On the debate over the 'valley of death' problem facing innovation." http://www.rieti.go.jp/jp/events/bbl/05020101.html (accessed October 27, 2017)

cited in US company patents were from universities, government agencies, and public research institutions, demonstrating the significant contribution of academic research to industry.

3.6 Characteristics of the pharmaceutical and biotechnology sectors

The results of surveys conducted by Mansfield (1991) and Mansfield (1998) indicate that pharmaceutical and medical sectors are considered to be the industry sectors with the highest potential for the industrial application of knowledge generated by basic research. Approximately 31 percent of products could not have been developed without the results of academic research, the largest value among all industries surveyed, compared to the average of 15 percent for all industries surveyed between 1986 and 1994.

The results of a survey by Klevorick et al. (1995) revealed pharmaceuticals to be the industry in which science and business are closest. Analyzing the patent citations of publicly traded biotechnology companies in the US, McMillan et al. (2000) found that biotechnology companies rely more heavily on public research and basic science than companies in other industries. These results show that the link between academic research and innovation is stronger in pharmaceutical and biotechnology companies than in companies in other industries.

As noted earlier, Cohen and Levinthal (1990) found that conducting basic research in-house is an effective means for companies to increase their ability to absorb external knowledge. However, subsequent interviews with pharmaceutical companies showed that companies wishing to take advantage of the results of publicly funded research must not simply invest in basic research in-house, but actively collaborate with publicly funded researchers (Cockburn and Henderson, 1998). Cockburn and Henderson (1998) examined the number of co-authored papers among pharmaceutical companies and publicly funded researchers as an indicator of the extent of collaboration, demonstrating that this indicator was positively correlated with company-side research output (i.e., number of important patents per research expenditure).

Saito and Sumikura (2010) developed an index of the strength of each company's tendency to try to obtain academic research based on the status of joint patent applications between universities and Japanese pharmaceutical companies, and analyzed this index as an explanatory variable to show that academic research improves the performance of corporate R&D. However, there is no evidence that the frequency of academic research acquisition has a significant positive effect on the number of new pharmaceuticals created, suggesting that there are discontinuities between R&D and pharmaceuticals development in pharmaceutical companies that are unable to effectively obtain academic research.

What is the economic and social impact of such public spending on academic research in the pharmaceutical and biotechnology sectors? In a survey and analysis of the existing literature, Cockburn and Henderson (2001) found that the annual rate of return on public expenditure on biomedical research in the US is at least 30 percent. Toole (2012) conducted an analysis using data from 1955 to 1996 on National Institutes of Health (NIH) funding of basic research by academia in the life sciences, data on R&D investment by pharmaceutical companies, and data on the creation of new pharmaceuticals, finding that NIH funding of basic research, the size of potential markets, and industry R&D spending all contribute positively to the creation of new pharmaceuticals. The study estimated that a 1 percent increase in public spending on basic research would result in a 1.8 percent increase in the creation of new pharmaceuticals. In fact, many drugs are created based on the results of research in academia. According to Stevens et al. (2011), 143 (9.3%) of the 1541 drugs approved by the Food and Drug Administration (FDA) between 1990 and 2007 were produced through research at universities and public research institutions, providing evidence that public spending on life science research has a certain economic and social impact in the US.

References

Branscomb, L. and Auerswald, P. (2001). Taking technical risks: How innovators, executives and investors manage high-tech risks, Cambridge, ma. MIT Press.
https://mitpress.mit.edu/books/taking-technical-risks

Cockburn, I. M. and Henderson, R. M. (1998). Absorptive capacity, coauthoring behavior, and the organization of research in drug discovery. Journal of Industrial Economics, 46(2):157–182.
https://onlinelibrary.wiley.com/doi/abs/10.1111/1467-6451.00067

Cockburn, I. M. and Henderson, R. M. (2001). Publicly funded science and the productivity of the pharmaceutical industry. In Jaffe, A. B., Lerner, J., and Stern, S., editors, Innovation policy and the economy, volume 1, pages 1–34. MIT Press.
http://www.nber.org/chapters/c10775.pdf

Cohen, W. M. and Levinthal, D. A. (1990). Absorptive capacity: A new perspective on learning and innovation. Administrative Science Quarterly, 35(1):128–152.
https://www.sciencedirect.com/science/article/pii/B9780750672238500058

Committee on Science, US House of Representatives, O.H.F.C. (1998). Unlocking our future: Toward a new national science policy.
https://www.aaas.org/sites/default/files/migrate/uploads/GPO-CPRT-105hprt105-b.pdf

Fawcett, S. L. (1985). Macro-engineering projects in a free society. Technology in Society, 7(4):361–371.
https://www.sciencedirect.com/science/article/pii/0160791X85900041

Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P., and Trow, M. (1994). The new production of knowledge: The dynamics of science and research in contemporary societies. Sage. (Japanese translation: M. Gibbons (ed.), Kobayashi Shinichi (1997), Gendai shakai to chi no sōzō―mōdo-ron to wa nani ka―, Maruzen.
https://books.google.com/books/about/The_New_Production_of _Knowledge.html?id=KS_caFqMFoMC

Grimaldi, R., Kenney, M., Siegel, D. S., and Wright, M. (2011). 30 years after bayh–dole: Reassessing academic entrepreneurship. Research Policy, 40(8):1045–1057.
https://www.sciencedirect.com/science/article/pii/S0048733311000874

Jaffe, A. B. (1989). Real effects of academic research. The American Economic Review, 957–970.
http://dimetic.dime-eu.org/dimetic_files/JaffeAER1989.pdf

Klevorick, A. K., Levin, R. C., Nelson, R. R., and Winter, S. G. (1995). On the sources and significance of interindustry differences in technological opportunities. Research Policy, 24(2):185–205.

https://www.sciencedirect.com/science/article/pii/004873339300762I

Loise, V. and Stevens, A. J. (2010). The Bayh-Dole Act turns 30. Science Translational Medicine, 2(52):52–27.
http://stm.sciencemag.org/content/2/52/52cm27.short

Mansfield, E. (1991). Academic research and industrial innovation. Research Policy, 20(1):1–12.
https://www.sciencedirect.com/science/article/pii/004873339190080A

Mansfield, E. (1998). Academic research and industrial innovation: An update of empirical findings. Research policy, 26(7-8):773–776.
http://sjbae.pbworks.com/f/Mansfield_1998.pdf

McMillan, G. S., Narin, F., and Deeds, D. L. (2000). An analysis of the critical role of public science in innovation: The case of biotechnology. Research Policy, 29(1):1–8.
http://www.sristi.org/material/9.2an%20analysis.pdf

Mowery, D. C., Nelson, R. R., Sampat, B. N., and Ziedonis, A. A. (2001). The growth of patenting and licensing by US universities: An assessment of the effects of the Bayh-dole Act of 1980. Research Policy, 30(1):99–119.
https://www.sciencedirect.com/science/article/pii/ S0048733399001006

Nagaoka, S., Igami, M., Walsh, J. P., and Ijichi, T. (2011). Knowledge creation process in science: Key comparative findings from the Hitotsubashi-NISTEP-Georgia Tech Scientists' Survey in Japan and the US. IIR Working Paper No. 11-09, Institute of Innovation Research, Hitotsubashi University.
http://hermes-ir.lib.hit-u.ac.jp/rs/bitstream/10086/19402/3/ 070iirWP11_09.pdf

Narin, F., Hamilton, K. S., and Olivastro, D. (1997). The increasing linkage between us technology and public science. Research Policy, 26(3):317–330.
https://www.researchgate.net/profile/Francis_Narin/publication/247909063_The_increasing_link_between_U_S_technology_and_public_science/links/56aafe7c08aeadd1bdcafd88/The-increasing-link-between-U-S-technology-and-public-science.pdf

Roessner, D., Bond, J., Okubo, S., and Planting, M. (2009). The economic impact of licensed commercial inventions resulting from university research, 1996–2007. Final Report to the Biotechnology Industry Organization.
https://www.bio.org/sites/default/files/Study _on_Economic_Impact_Bayh-Dole.pdf

Saito, H. and Sumikura, K. (2010). An empirical analysis on absorptive capacity based on linkage with academia. International Journal of Innovation Management, 14(3):491–509.
https://www.researchgate.net/publication/46510867_An_empirical_analysis_on_absorptive_capacity_based_on_linkage_with_academia

Stevens, A. J., Jensen, J. J., Wyller, K., Kilgore, P. C., Chatterjee, S., and Rohrbaugh, M. L. (2011). The role of public-sector research in the discovery of drugs and vaccines. New England Journal of Medicine, 364(6):535–541.
https://www.nejm.org/doi/full/10.1056/NEJMsa1008268

Stokes, D. E. (1997). Pasteur's quadrant: Basic science and technological innovation. Brookings Institution Press.
https://books.google.co.jp/books/about/Pasteur_s_Quadrant.html?id=TLKDbvJX86YC&redir_esc=y; https://philpapers.org/rec/STOPQB

Toole, A. A. (2012). The impact of public basic research on industrial innovation: Evidence from the pharmaceutical industry. Research Policy, 41.
https://www.sciencedirect.com/science/article/pii/S004873331100117X

Yoshida, R. (2016). Nobel winner Yoshinori Ohsumi urges investment in science.
https://www.japantimes.co.jp/news/2016/10/04/national/science-health/nobel-winner-yoshinori-ohsumi-urges-investment-science/

Zucker, L. G. and Darby, M. R. (2001). Capturing technological opportunity via Japan's star scientists: Evidence from Japanese firms' biotech patents and products. *The Journal of Technology Transfer*, 26(1-2):37–58.
https://link.springer.com/article/10.1023/A:1007832127813

Zucker, L. G., Darby, M. R., and Armstrong, J. S. (2002). Commercializing knowledge: University science, knowledge capture, and firm performance in biotechnology. *Management Science*, 48(1):138–153.
https://pubsonline.informs.org/doi/pdf/10.1287/mnsc.48.1.138 .14274

Sumikura, Koichi (2003), Chiteki zaisan-ken o mekiki suru "ensuikei jinzai" ga Nihon o kaeru: Daigaku wa "chiteki zaisan" todo no yō ni mukiaubeki ka [Conical human resources judging intellectual property rights are changing Japan: How universities should face "intellectual property"], Illume, 30:4
https://ci.nii.ac.jp/naid/10021357020/

Sumikura Koichi and Saito Hiromi (2014), Akademikku narejji wa inobēshon ni kōken shite iru ka? Raifu Saiensu ni motodzuku seiyaku baio no inobēshon sōshutsu ni mukete [Does academic knowledge contribute to innovation? Toward the creation of pharmaceutical and bio-innovations rooted in life science], Intellectual Property Association of Japan Intellectual Property Seminar Editorial Board (ed.), A prospect of studies on intellectual property and innovation, pp. 209–235, Hakuto-shobo.
http://www.hakutou.co.jp/book/b186001.html [In Japanese]

Furuya Maho and Watanabe Toshiya. (2014). Baidōru seido no kakkoku hikaku [A per-country comparison of the Bayh-Dole System]
http://pari.u-tokyo.ac.jp/unit/iam/outcomes/pdf/papers_140819furuya.pdf [In Japanese]

Takahashi Makiko, Furusawa Yoko, Edamura Kazuma and Sumikura Koichi. (2018). Human resources for research promotion and utilization in Japanese academia: From competition to cooperation of university-industry cooperation coordinators and university research administrators (URA). GRIPS DISCUSSION PAPER 18-11, GRIPS.
https://grips.repo.nii.ac.jp/?action=repository_uri&item_id= 1648&file_id=20&file_no=1 [In Japanese]

Kobayashi Shinichi. (1999). Kagaku gijutsu no mōdo-ron no haikei to tenkai [The background and development of the modal theory of science and technology]. Materia, 38(11):830–833. https://doi.org/ [In Japanese]

National Center for Industrial Property Information and Training. (2010). Kenkyū kaihatsu konsōshiamu ni okeru chizai purode~yūsa no arikata ni kansuru kenkyūkai hōkoku-sho [Report of the study group on "IP producers in R&D consortia]. https://www.inpit.go.jp/content/100165200.pdf [In Japanese]

Related data sources

The State of Industry-Academia Collaboration at Universities and Other Institutions (FY2003–FY2017, annual)
http://www.mext.go.jp/a_menu/shinkou/sangaku/sangakub.htm [In Japanese]

Information on related base course subjects and research projects

National Graduate Institute for Policy Studies Lecture: Policy for Higher Education and University-Industry Cooperation (Lecturer: Sumikura Koichi)

National Graduate Institute for Policy Studies Lecture: Roles of Intellectual Property Rights in a Globalized World (Lecturer: Sumikura Koichi)

Policy Research Project Center, National Graduate Institute for Policy Studies (GRIPS), Research Project: "Research Project on the Effects of University Professional Staff on the Acquisition of External Funds and Industry-Academia Collaboration" (FY2016–2017; Lead researcher: Sumikura Koichi)

Grant-in-Aid for Scientific Research, Basic Research (B), "Analysis of the Determinants of University Research Resources Acquisition, the Creation of Research Results, and Social Returns" (FY2018–FY2021; Lead researcher: Sumikura Koichi)

Policy Research Project Center, National Graduate Institute for Policy Studies Long-term Science Council-supported Project: "Study Group on the Development of Human Resources for Industry-Academia Collaboration (Society for Management of Intellectual Properties: SMIPS)" (FY2009–2019; Project leader: Sumikura Koichi) *The study group itself has been held since April 2000.
http://www.smips.jp/