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ASSESSING THE EFFICACY OF THE BAYH-DOLE ACT THROUGH THE LENS OF UNIVERSITY TECHNOLOGY TRANSFER OFFICES (TTOS)

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Universities are unique environments that thrive on the research and curiosity of faculty and students. To disseminate knowledge and potentially derive lucrative sources of funding, universities have aggressively entered the field of technology commercialization and patenting. The passage of the Bayh-Dole Act was instrumental to encourage this activity and the result has been an explosion of university-related patenting. This activity comes at a social cost, however, since patents restrict knowledge transfers and may create deadweight losses. These costs are amplified if technology transfer office (TTO) activities are viewed from a narrow financial or cost-benefit viewpoint. As demonstrated in this study, twenty institutions belong to an elite grouping of leader institutions that have financially sustainable TTO operations. The rest are classified as laggards and consistently operate with losses.

This article examines why the leaders excel and why the laggards continue to support TTO activities when they present a financial drain on universities. Transaction cost economics, institutional theory, signaling, and expected value theory can all offer insights related to the organization and maintenance of these offices. These theoretical perspectives help to explain why universities engage in technology transfer. An in-depth examination of the highly successful Taxol case at Florida State University, a

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laggard institution, sheds light on some of the antecedents for a successful, yet rare, technology transfer event. The case reinforces the view that technology transfer should not be viewed narrowly, even among laggard institutions, but rather it should be viewed as a strategic endeavor that involves signaling, the observance of social conventions and investment for broader technological and economic objectives.

Two negative consequences have resulted despite the success of Bayh-Dole. These include the increasingly predatory and commercial behavior of universities and the highly-skewed distribution of value among TTOs. If left unaddressed, these problematic results may result in legislative reforms that could weaken the ability of universities to practice technology transfer.

I. INTRODUCTION

University-based patenting and technology transfer have received considerable attention due to several extraordinary success stories.[1] Google, for example, offers a compelling university technology transfer story. In that case, Sergei Brin and Larry Page's initial search and webpage ranking algorithm was patented by Stanford University when this pair of enterprising doctoral students

[1] *See, e.g.*, Rebecca S. Eisenberg, *Patents and the Progress of Science: Exclusive Rights and Experimental Use*, 56 U. CHI. L. REV. 1017, 1018 (1989) (stating that "[t]he biotechnology revolution has accelerated the commercial development of basic research discoveries and attracted commercial interest in academic biomedical research in its early stages."); Peter Lee, *Patents and the University*, 63 DUKE L.J. 1, 4–5 (2013); Arti K. Rai, *Regulating Scientific Research: Intellectual Property Rights and the Norms of Science*, 94 NW. U. L. REV. 77, 109–115 (1999). Technology transfer, broadly construed, involves the dissemination of technology to a third party. This can occur without patents such as in the case of trade secret licensing or through more informal knowledge-sharing methods such as publishing a paper or technical consulting. This article focuses on technology transfer related to patent licensing within U.S. research-oriented universities and any references to technology transfer will pertain to this more limited context, unless otherwise stated.

were employed by the university.[2] This groundbreaking patent was later licensed exclusively by Stanford to Google, the company subsequently founded by Brin and Page with the backing of investors to commercialize their patented webpage ranking algorithm.[3] In exchange for a long-term exclusive license to the patent, Google offered Stanford 1.8 million shares of Google stock.[4] Several other, more recent "blockbuster" examples of university technology transfer include Northwestern University's discovery of pregabalin, marketed by Pfizer as Lyrica that resulted in $1.4 billion in licensing income and New York University's patents related to the drug Remicade, which resulted in more than $1 billion in royalties to the university.[5]

As these cases demonstrate, the incentive for universities to engage in technology transfer are powerful since the payoffs can be remarkable.[6] These powerful incentives motivated universities to devote significant attention and resources to costly technology transfer activities, such as patenting and technology commercialization. According to one survey by the Association of University Technology Managers (AUTM), U.S. universities spent a total of $368 million on legal patenting fees in just one year.[7] However, patents can be costly to society and universities since they

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[2] U.S. Patent No. 6,285,999 (filed Jan. 9, 1998).

[3] Google's webpage ranking algorithm patent was eventually integrated into a viable business model that connected online search with paid advertising through Google's Adwords and Adsense programs. *See* Will Oremus, *Google's Big Break*, SLATE (Oct. 13, 2013), https://slate.com/business/2013/10/googles-big-break-how-bill-gross-goto-com-inspired-the-adwords-business-model.html [https://perma.cc/N297-L3VH].

[4] BEST PRACTICES IN STATE AND REGIONAL INNOVATION INITIATIVES: COMPETING IN THE 21ST CENTURY 226 (Charles W. Wessner ed., 2013).

[5] Richard Perez-Pena, *Patenting Their Discoveries Does Not Pay Off for Most Universities, a Study Says*, N.Y. TIMES (Nov. 21, 2013), http://www.nytimes.com/2013/11/21/education/patenting-their-discoveries-does-not-pay-off-for-most-universities-a-study-says.htm [https://perma.cc/RZT7-2KGY].

[6] WALTER D. VALDIVIA, BROOKINGS INST., UNIVERSITY START-UPS: CRITICAL FOR IMPROVING TECHNOLOGY TRANSFER 1, 11 (2013) ("Stories of blockbuster patents have fueled the ambition of TTO heads and university administrators . . . .").

[7] ASS'N OF UNIV. TECH. MANAGERS, AUTM LICENSING SURVEY 38 (2014).

offer limited-life exclusivity rights and restrict the use of technologies.[8] If patents prevent others from practicing an invention, this can create a "deadweight loss" on society.[9] These societal losses are so pronounced that universities that patent and aggressively enforce their rights against others have even been described as "patent trolls."[10]

The reality, however, is that research universities increasingly devote substantial resources and employ on campus technology transfer offices (TTOs) to handle the patenting and commercialization of university-related inventions.[11] For many years, the practice of patenting and commercialization was viewed outside the purview of the research university's ethical mission to conduct basic research that should be offered unencumbered to the

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[8] *See* Ian Ayres & Lisa L. Ouellette, *A Market Test for Bayh-Dole Patents*, 102 CORNELL L. REV. 271, 281 (2017) (stating that patents "create deadweight loss because they are effective only to the extent they give patentees some market power that allows prices to be raised above marginal cost"); *see* Rebecca S. Eisenberg, *Public Research and Private Development: Patents and Technology Transfer in Government-Sponsored Research*, 82 VA. L. REV. 1663, 1666 (1996) (arguing that allowing private firms to hold exclusive patent rights requires the public "to pay twice for the same invention-once through taxes to support the research that yielded the invention, and then again through higher monopoly prices and restricted supply when the invention reaches the market"); *see* Cristina Weschler, *The Informal Experimental Use Exception: University Research After Madey v. Duke University*, 79 N.Y.U. L. REV. 1536, 1543 (2004) (discussing a controversial federal appellate court decision whereby Duke University "would not be entitled to rely on the experimental use defense if its use of the patented materials was in furtherance of its 'legitimate business objectives,' which it defined to include 'educating and enlightening students and faculty,' 'increas[ing] the status of the institution and lur[ing] lucrative research grants.'").

[9] *See* Ayres & Ouellette, *supra* note 8, at 281.

[10] Mark A. Lemley, *Are Universities Patent Trolls?*, 18 FORDHAM INTELL. PROP. MEDIA & ENT. L.J. 611, 611 (2008). In one recent high-profile example, Carnegie Mellon University was awarded a $750 million dollar settlement to end a patent dispute. *See* Joe Mullin, *Marvell Agrees to Pay Record-Breaking $750M to University to End Patent Lawsuit*, ARS TECHNICA (Feb. 18, 2016), https://arstechnica.com/tech-policy/2016/02/marvell-will-pay-750m-to-carnegie-mellon-university-in-massive-patent-settlement/ [https://perma.cc/9CQP-CKEL].

[11] Ayres & Ouellette, *supra* note 8, at 273 ("Today, every major U.S. research institution has a technology transfer office . . . .").

public.[12] A tension arises since the appropriation and commercial exploitation of intellectual property rights contravenes the basic goals and tenets of open scientific research that most research-oriented universities support.[13] Compounding the problem of social cost is the fact that few TTOs are profitable.[14] Year-after-year and with few exceptions, TTOs draw scarce and valuable resources that could be used to support other useful university-related activities such as faculty research, scholarships, and instruction.

Technology transfer within universities was facilitated by the passage of the Bayh-Dole Act.[15] This federal statute gave universities the right to own inventions supported with federal research funds and grant exclusive licenses to these inventions.[16] This article will assess the efficacy of Bayh-Dole in light of the

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[12] Jay P. Kesan, *Transferring Innovation*, 77 FORDHAM L. REV. 2169, 2170 (2009) (stating that prior to 1980 "open science norms, along with the somewhat complicated procedure of obtaining title to government-funded inventions, likely resulted in a very low emphasis on patenting university research"); *see also* ARCHIE M. PALMER, NONPROFIT RESEARCH AND PATENT MANAGEMENT IN THE UNITED STATES 43–44 (1956) ("Most universities and other nonprofit research organizations endeavor to avoid becoming involved in the intricate technical and commercial aspects of patent management, mainly because they do not have the personnel with the requisite specialized knowledge and experience . . . . When patent protection is necessary, it is natural for educational institutions, as well as other nonprofit research organizations, to make every effort to avoid becoming directly involved in the intricate legal and commercial aspects of patent management.").

[13] PALMER, *supra* note 12, at 5 ("Whether concerned primarily with search into the unknown for a new idea, understanding of nature and its laws, solution of a specific research problem, development of a new product or improvement of an existing process, most scientists working in university laboratories and in nonprofit research organizations are content to pursue their investigations without giving much, if any, thought to the patentability of the results. Their research efforts are directed primarily to the task at hand and many take the attitude that wide dissemination of the results through publication is preferable.").

[14] VALDIVIA, *supra* note 6, at 9.

[15] Bayh-Dole Act of 1980, 35 U.S.C. §§ 200–12 (2012).

[16] *See* DAVID C. MOWERY, RICHARD R. NELSON, BHAVEN N. SAMPAT & ARVIDS A. ZIEDONIS, IVORY TOWER AND INDUSTRIAL INNOVATION: UNIVERSITY-INDUSTRY TECHNOLOGY TRANSFER BEFORE AND AFTER THE BAYH-DOLE ACT IN THE UNITED STATES 53 (2004); *see also* Gary Pulsinelli, *Share and Share Alike: Increasing Access to Government-Funded Inventions Under the Bayh-Dole Act*, 7 MINN. J. L. SCI. & TECH. 393, 398–99 (2006).

statute's purpose, which is to stimulate greater technology commercialization of federally-funded research. An impetus for the passage of this law was to stimulate greater commercialization efforts, particularly among universities, connect universities with industry and generate greater funding for additional research.[17] Another ancillary goal of this legislation was to provide the public with more benefits from university research through commercialization.[18] The result after the statute's passage was an overall dramatic increase in university patenting.[19]

To facilitate commercialization, universities delegated the authority to manage university-owned intellectual property rights internally to TTOs. These offices are typically comprised of attorneys who specialize in licensing, contract-drafting, patenting and commercialization efforts vis-a-vis third-party businesses interested in licensing university-owned intellectual property. Staffing TTOs within universities is a yearly expense that amounts to several hundreds of thousands of dollars in addition to the legal patenting costs incurred through the use of external patent counsel.[20]

Despite the increased rate of patenting within academic institutions, few TTOs generate enough revenue to offset their expenses.[21] There are a few universities that earn a profit on technology transfer and these are referred to as *leaders* in this article since they persistently operate in a profitable manner.[22] Most

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[17] *See* MOWERY ET AL., *supra* note 16, at 92–93.

[18] *See* Margo A. Bagley, *Academic Discourse and Proprietary Rights: Putting Patents in Their Proper Place*, 47 B.C. L. REV. 217, 232 (2006); Arti Kaur Rai, *Regulating Scientific Research: Intellectual Property Rights and the Norms of Science*, 94 NW. U. L. REV. 77, 97 (1999).

[19] Michael S. Mireles, Jr., *States as Innovation System Laboratories: California, Patents, and Stem Cell Technology*, 28 CARDOZO L. REV. 1133, 1149 (2006); Kristen Osenga, *Rembrandts in the Research Lab: Why Universities Should Take a Lesson from Big Business to Increase Innovation*, 59 ME. L. REV. 407, 419 (2007) (stating that between 1988–2003 patents assigned to universities rose from 800 patents to 3,200).

[20] At the author's institution (Florida State University) the budget for the Office of Technology Commercialization nears $500,000 a year. This does not factor the considerable attorney's fees spent every year to patent the university's inventions.

[21] Bagley, *supra* note 18, at 234; Valdivia, *supra* note 6, at 9.

[22] *See infra* pp. 13–16.

university technology transfer activities create losses and thus most universities fit within the category of *laggards*.[23]

As explained below, the Bayh-Dole Act provided effective property rights-based incentives to commercialize university inventions.[24] The statute, however, failed to anticipate a challenge facing TTOs in relation to the unique institutional setting of academia.[25] Academic inventors generally have a different perspective on innovation since they prioritize knowledge dissemination under open science norms and rely on these norms to further their research.[26] Academic inventors also place a greater value on their status among academic peers and their reputation through contributions to basic research that often involve publications.[27] Academics respond to other strong incentives to innovate such as tenure and promotion, awards and prestige.[28] Technology transfer offices, therefore, struggle to convince academic inventors to employ the patent system since it often results in agreements that restrict knowledge among the broader scientific community.[29] For example, patents may prevent other scientists

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[23] *Id*.

[24] *See* Harold Demsetz, *Toward a Theory of Property Rights*, 57 AM. ECON. REV. 347, 357 (1967) (stating the "[t]he reduction in negotiating cost that accompanies the private right to exclude others allows most externalities to be internalized at rather low cost" and the Bayh-Dole Act greatly reduced the cost of internalizing externalities by allowing exclusive licenses to be awarded).

[25] *See* Janet Bercovitz & Maryann Feldmann, *Entrepreneurial Universities and Technology Transfer: A Conceptual Framework for Understanding Knowledge-Based Economic Development*, 31 J. TECH. TRANSFER 175, 180 (2006) ("Faculty members may not disclose, [inventions to a TTO] because they believe that commercial activity is not appropriate for an academic scientist. This view certainly represents the established norms of open academic science that favour publication over patenting.").

[26] *See* Weschler, *supra* note 8, at 1545.

[27] Kira R. Fabrizio & Alberto Di Minin, *Commercializing the Laboratory: Faculty Patenting and the Open Science Environment*, 37 RES. POL'Y 914, 914 (2008).

[28] *See* Lemley, *supra* note 10, at 621.

[29] *See* Danny Hakim, *Scientists Loved and Loathed by an Agrochemical Giant*, N.Y. TIMES (Dec. 31, 2016), https://www.nytimes.com/2016/12/31/business/scientists-loved-and-loathed-by-syngenta-an-agrochemical-giant.html [https://perma.cc/76XD-P5AG].

from using technologies that are applicable to their fields of research.

Scholars disagree about the merits of university-based technology transfer. On one hand, some scholars believe that the costs of patenting outweigh the benefits.[30] For these scholars, the costs include the resources spent to patent and litigate these rights. Also, their view is that the restrictions on technology use hinder innovation and contribute to the tragedy of the commons.[31] The costs extend beyond economics since the university culture, which is based on knowledge sharing, transparency, and public welfare can be damaged if too much emphasis is placed on private interests and technology commercialization.[32] According to these scholars, academic interests suffer when universities myopically focus on licensing or revenue generation.[33]

Other scholars disagree and view technology commercialization as an overall benefit to society and universities. To these individuals,

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[30] *See, e.g.*, Ted Agres, *The Costs of Commercializing Academic Research: Does University Licensing Impede Life Science Research and Development?*, SCIENTIST (Aug. 25, 2003), https://www.the-scientist.com/profession/the-costs-of-commercializing-academic-research-51183 [https://perma.cc/28NU-8YC3] (quoting Paul Berg, Director Emeritus, Beckman Center for Molecular and Genetic Medicine, Stanford University); Rochelle Dreyfuss, *Protecting the Public Domain of Science: Has the Time for an Experimental Use Defense Arrived?*, 46 ARIZ. L. REV. 457, 464 (2004) (stating that the Bayh-Dole Act was "enacted to promote technology transfer through licensing, and not specifically to enrich universities") (citing Rebecca S. Eisenberg, *Public Research and Private Development: Patents and Technology Transfer in Government-Sponsored Research*, 82 VA. L. REV. 1663, 1663 (1996)); Mark A. Lemley, *Patenting Nanotechnology*, 58 STAN. L. REV. 601, 628 (2005); John M. Golden, *Biotechnology, Technology Policy, and Patentability: Natural Products and Invention in the American System*, 50 EMORY L.J. 101, 108–10 (2001).

[31] Michael A. Heller & Rebecca S. Eisenberg, *Can Patents Deter Innovation? The Anticommons in Biomedical Research*, 280 SCIENCE 698, 698 (1998) (addressing the concern that an excess of rights in a resource could lead to underuse).

[32] *See* Kesan, *supra* note 12, at 2192 ("Scholars have also noted the danger of possible interference with academic freedom and academic priorities.").

[33] *See, e.g.*, Megan Ristau Baca, *Barriers to Innovation: Intellectual Property Transaction Costs in Scientific Collaboration*, 2006 DUKE L. & TECH. REV. 4, 4 (2006); Mark A. Lemley, *Are Universities Patent Trolls?*, 18 FORDHAM INTELL. PROP. MEDIA & ENT. L.J. 611, 618 (2008).

the benefits that accrue from university patents outweigh the substantial costs.[34] These benefits are measured as resources granted to the university in terms of royalties and partnerships with industry. The benefits also extend beyond the university as society benefits from the application of new technologies and enterprises. For example, a 2013 study found that universities had created 3,715 spin-off companies.[35] Also, entire industries such as biotechnology have benefited greatly from university patent licensing under the Bayh-Dole Act.[36] According to one source, nearly half of biotech firms owe their genesis to university-related inventions.[37] These measures indicate that social welfare is increased by university technology transfer activities.

There is continuing debate concerning the overall social benefits of Bayh-Dole, and finding an answer to this question depends to some extent on how one defines the problem. If the issue is narrowly defined as whether universities on average profit from patent licensing, the answer is that university patenting is inefficient and irrational.[38] On the other hand, if the issue is framed more broadly as overall enterprise formation and royalty generation, the answer is that technology transfer is efficient. The problem, however, is distributional since very few universities can financially justify their

[34] *See generally* Adam B. Jaffe, Manuel Trajtenberg & Rebecca Henderson, *Geographic Localization of Knowledge Spillovers as Evidenced by Patent Citations*, 108 Q.J. ECON. 577–98 (1993); F. Scott Kieff, *Facilitating Scientific Research: Intellectual Property Rights and the Norms of Science—A Response to Rai and Eisenberg*, 95 NW. U. L. REV. 691 (2001); David C. Mowery et al., *The Growth of Patenting and Licensing by U.S. Universities: An Assessment of the Effects of the Bayh-Dole Act of 1980*, 30 RES. POL'Y 99 (2001); Osenga, *supra* note 19, at 418.

[35] ASS'N OF UNIV. TECH. MANAGERS, AUTM LICENSING SURVEY (2013).

[36] *See* Mary Eberle, *March-in Rights Under the Bayh-Dole Act: Public Access to Federally Funded Research*, 3 MARQUETTE INTELL. PROP. REV. 155, 155 (1999).

[37] Bio Tech. Indus. Org., *BIO 2009 Member Survey Technology Transfer & the Biotechnology Industry* (2009), https://www.bio.org/articles/bio-2009-member-survey-technology-transfer-and-biotechnology-industry [https://perma.cc/Q6JU-7V4M].

[38] Valdivia, *supra* note 6, at 1.

TTO-related expenses and this yields a winner-take-all type of environment.[39]

This article seeks to provide additional insights to the debate concerning the efficacy of Bayh-Dole by addressing and answering the following questions: 1) Which universities gain from technology transfer? 2) Since technology transfer is narrowly defined as a losing financial proposition at most institutions (even very well-funded ones), why do so many universities engage in this behavior? 3) Is university-based technology transfer desirable from a social welfare perspective? 4) Should law and policy be calibrated to encourage or rein in university-based technology transfer?

To answer these important questions, Part II of this article will first examine the origins of the Bayh-Dole Act and how it impacted university technology transfer practices. Part III will examine the academic institutional setting of technology transfer. Part IV will discuss the organizational attributes, success factors and obstacles related to TTOs within universities. Data will be examined to analyze the skewed distribution of successful technology transfer cases at leader institutions. Several factors are analyzed to determine the reasons why technology transfer at universities remains an elusive prospect and why so many laggard institutions continue to invest in this speculative and costly activity. In Part V, transaction cost economics, institutional theory, signaling and expected value theory will explain what seems like irrational behavior at laggard universities. Part VI provides an in-depth case study analysis related to Taxol, a successful and unique technology transfer event at Florida State University. This case brings to light the relevant antecedents and subsequent events that might follow a rare technology transfer success at a laggard institution. Part VII will discuss various legal and policy implications that arise from the analysis.

[39] *Id*. at 14.

II. TECHNOLOGY TRANSFER IN LIGHT OF THE BAYH-DOLE ACT

A. The Forces Behind the Passage of the Bayh-Dole Act

A principal goal for the passage of the Bayh-Dole Act was to stimulate greater commercialization efforts among universities, connect universities with industry, and to generate greater funding for research.[40] For example the statute states:

> It is the policy and objective of the Congress to use the patent system to promote the utilization of inventions arising from federally supported research or development; to encourage maximum participation of small business firms in federally supported research and development efforts; to promote collaboration between commercial concerns and nonprofit organizations, including universities; to ensure that inventions made by nonprofit organizations and small business firms are used in a manner to promote free competition and enterprise . . . . [41]

To achieve these goals the act stated that universities would be authorized to patent and license federally-funded research.[42] From the outset, universities played a major role in the sponsorship of the Bayh-Dole Act. According to one scholar:

> [a] number of universities, including Harvard University, Stanford University, the University of California, and the Massachusetts Institute of Technology, lobbied for passage of the bill, and throughout the debates representatives of these and other research universities were active in "commenting and helping to develop the final language" of the House and Senate versions of the bill.[43]

B. Technology Transfer Pre-Bayh-Dole

It is widely recognized that a singular moment for university technology transfer was the passage of the Bayh-Dole Act in 1981.[44]

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[40] *See* MOWERY ET AL., *supra* note 16, at 85–99.

[41] 35 U.S.C. § 200 (1994).

[42] 35 U.S.C. §§ 200–12 (2012).

[43] DAVID C. MOWERY, *The Bayh-Dole Act and High-Technology Entrepreneurship in U.S. Universities: Chicken, Egg, or Something Else?,* 16 ADVANCES IN THE STUDY OF ENTREPRENEURSHIP 39, 50 (Gary D. Libecap ed., 2005).

[44] Kesan, *supra* note 12, at 2174 ("From a patent standpoint, the Bayh-Dole Act was a very significant piece of legislation during the 1980s, because it led to an increase in nonprofit organizations' involvement in the patent system.").

This federal act gave universities the exclusive patent rights to own inventions supported with federal research grants and the ability to offer exclusive licenses to these patented inventions.[45] With the exception of march-in rights retained by the federal government to practice a patented technology without the owner's permission, universities could patent and grant exclusive licenses to inventions funded with federal research grants.[46]

A handful of universities had successfully experimented with technology transfer prior to Bayh-Dole, for example: Stanford, MIT, the University of Wisconsin, and Purdue.[47] The general trend among state and private universities, however, was to increase technology transfer before Bayh-Dole's passage.[48] Other paths to deliver knowledge and transfer technology were and continue to remain important. For example, faculty publications, conference presentations, consulting engagements, and informal meetings are ways university scientists promote technology transfer without patenting.[49] Most commentators, however, agree that the passage of the Bayh-Dole Act was instrumental in facilitating university technology transfer and encouraged the explosive growth in university patenting.[50]

Universities were key stakeholders in the passage of the Act even though university licensing has and remains controversial in relation to open science norms.[51] This controversy dates back to 1933, when a report issued by the American Association for the Advancement of Science discussed technology commercialization

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[45] *Id.* at 2174–75.

[46] 35 U.S.C. § 200 (1994).

[47] MOWERY ET AL., *supra* note 16.

[48] *See* Scott Shane, *Encouraging University Entrepreneurship? The Effect of the Bayh-Dole Act on University Patenting in the United States*, 19 J. BUS. VENTURING 127, 128–29 (2004).

[49] *See* Peter Lee, *Transcending the Tacit Dimension: Patents, Relationships and Organizational Integration in Technology Transfer*, 100 CAL. L. REV. 1503, 1508 (2012); MOWERY ET AL., *supra* note 16.

[50] Lee, *supra* note 1, at 64 (discussing in detail how university administrators were involved throughout the Act's genesis and passage); Ayres & Oullette, *supra* note 8, at 272–73.

[51] ROBERT K. MERTON, THE SOCIOLOGY OF SCIENCE: THEORETICAL AND EMPIRICAL INVESTIGATIONS 464 (1973).

by universities and concluded that "it is unethical for scientists or professors to patent the results of their work."[52]

Dr. Harry Steenbock was a faculty member at the University of Wisconsin and he played a critical role to help that university establish the Wisconsin Alumni Research Foundation (WARF), the university's technology licensing arm in 1925. Dr. Steenbock helped launch WARF by transferring his patents to enrich milk with vitamin D. For many years Dr. Steenbock refused to receive royalties on his patents since he believed it would ethically compromise his position as an academic scientist.[53] In this way, Dr. Steenbock illustrated the early and prevailing norm within universities that sought to create a distance between the private commercialization aims of patenting and the public mission of university-related research activities.

C. Technology Transfer Post-Bayh-Dole

It is well-accepted that university patenting and technology commercialization were on the rise prior to the Bayh-Dole Act.[54] Prior to the Act, federal agencies had increased their levels of research funding and were looking for ways to commercialize research activities by partnering with industry, universities, and research institutes. For example, in 1986 Congress passed the Technology Transfer Act.[55] This act mandated that federal agencies with research programs take steps to transfer their technology for commercialization.[56] This act notably authorized federal agencies to enter into cooperative research and development agreements (CRADAs) with external institutions, including universities.[57] A

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[52] JOSEPH ROSSMAN & AM. ASS'N FOR THE ADVANCEMENT OF SCI., *The Protection by Patents of Scientific Discoveries*, *in* 79 SUPPLEMENT TO SCIENCE 8 (1934).

[53] Rima D. Apple, *Patenting University Research: Harry Steenbock and the Wisconsin Alumni Research Foundation*, 80 ISIS J. HIST. SCI. 374, 388 (1989).

[54] Kesan, *supra* note 12, at 2177.

[55] Federal Technology Transfer Act of 1986, Pub. L. No. 99–502, 100 Stat. 1785 (1986).

[56] FRED E. GRISSOM JR. & RICHARD L. CHAPMAN, MINING THE NATION'S BRAIN TRUST – HOW TO PUT FEDERALLY-FUNDED RESEARCH TO WORK FOR YOU 14 (1992).

[57] *Id*. at 15.

CRADA is a contract where an institution such as a corporation or a university contributes its research expertise to a federal laboratory to support an ongoing federal research program and obtains rights in any resulting inventions.[58]

Statistics support the argument that Bayh-Dole encouraged and amplified the pre-existing positive trend of university patenting and licensing.[59] Prior to the Bayh-Dole Act, there were only a handful of TTOs at universities, with several others outsourcing the function altogether to third parties such as the privately-owned Research Corporation.[60] Shortly after Bayh-Dole, almost all research universities established TTOs, with the number increasing eightfold to more than 200.[61] By 2005, the number of TTOs at universities, hospitals, and research institutes totaled 3,300.[62] New patent applications at universities have skyrocketed; an AUTM study reported that in 2014, 15,953 new patent applications were filed by universities.[63] Some of largest patentees belong to the TTO leader category discussed below. For example, the Massachusetts Institute of Technology obtained 360 patents in 2018.[64]

III. THE INSTITUTIONAL SETTING OF UNIVERSITY TECHNOLOGY TRANSFER

This part provides the necessary background to examine patenting and TTOs within a university context. As will be demonstrated, the proponents of the Bayh-Dole Act failed to anticipate the challenges of patenting in a university setting.

The backdrop of academic research and invention provides a strikingly unique setting. Unlike private industry, academia has various competing goals that can constrain technology

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[58] Thomas N. Bulleit Jr., *Public-Private Partnerships in Biomedical Research: Resolving Conflicts of Interest Arising under the Federal Technology Transfer Act of 1986*, 4 J.L. & HEALTH 1, 2 (1989-90).

[59] Kesan, *supra* note 12, at 2178.

[60] MOWERY ET AL., *supra* note 16, at 58–85.

[61] ASS'N OF UNIV. TECH. MANAGERS, AUTM LICENSING SURVEY (2014).

[62] Osenga, *supra* note 19, at 419.

[63] ASS'N OF UNIV. TECH. MANAGERS, AUTM LICENSING SURVEY (2015).

[64] MIT Facts, *MIT and Industry*, MIT, https://web.mit.edu/facts/industry.html [https://perma.cc/8CPL-SUQQ].

commercialization. First, university research funding differs from the private sector since a considerable portion of academic research is funded through grants.[65] Once they secure a research grant, university researchers do not have a strong incentive to secure a patent.[66] In this context, funding is assured once the research grant is approved. Commercialization efforts are, therefore, an afterthought to this process.

The legal entity status of research-oriented universities supports this paradigm since they are organized either as private non-profit entities or public state-affiliated entities subject to legislative oversight. Universities do not face the fiduciary decision-making constraint to optimize wealth-maximization that is present in private business.[67] Instead, universities view their primary mission as the creation and dissemination of knowledge and in terms of advancing public welfare.[68]

There is also an inventor selection bias since academic researchers are often drawn to university environments due to the freedom they have to pursue general knowledge-related inquiries traditionally labeled basic research.[69] This contrasts with most industrial research settings that emphasize applied research and a

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[65] *See* Eisenberg, *supra* note 8, at 1726 (stating that "[p]atent revenues account for a trivial fraction of overall university research budgets, while public research funding remains of critical importance.").

[66] Ayres & Ouellette, *supra* note 8, at 283–84.

[67] *See* Harvey J. Goldschmid, *The Fiduciary Duties of Nonprofit Directors and Officers: Paradoxes, Problems, and Proposed Reforms*, 23 J. CORP. L. 632, 641–43 (1997) ("For-profit directors and officers are principally concerned about long-term profit maximization, while nonprofit directors and officers, while keeping economic matters in mind, are principally concerned about the effective performance of the nonprofits's mission.").

[68] Lee, *supra* note 1, at 5 ("Throughout most of the history of the patent system, prudential interests in keeping foundational discoveries in the public domain as well as judicial recognition of the noncommercial nature of university science helped contribute to academic exceptionalism in patent doctrine.").

[69] *See* MOWERY ET AL., *supra* note 16, at 20 ("Basic research involves a quest for fundamental understanding. In the traditional natural sciences, such a quest has often been identified with research with no immediate concern with practical applications."). The term basic research originated from VANNEVAR BUSH, SCIENCE, THE ENDLESS FRONTIER (1945).

commercialization goal from the outset.[70] Some of the values academic researchers ascribe to include reputation among the scientific community, the prestige of academic research, making contributions to general knowledge, and the open norms of communicating and sharing research findings with other scientists.[71] The academic institutional setting encourages these values and norms through its incentive system of tenure and promotion awarded primarily for publications that generate basic research findings and citations among academic researchers. Whereas patents often play an important role in professional advancement within the private sector, they are rarely used for promotion and tenure purposes at leader or laggard universities.[72] To the contrary, academic prestige and promotion may be hindered if an academic researcher spends too much time and effort patenting their research.[73]

The distinctions among research orientation and motivations are visually captured in the matrix known as the Stokes Classification of Scientific Research.[74] This matrix represented as Figure 1 classifies research along two dimensions: considerations of use and the quest for basic knowledge. If an inventor does not emphasize use considerations (the applied nature of technology) and is motivated by a quest for basic understanding they fit within the pure basic research, or Bohr's quadrant. If the inventor has a quest for basic research and is interested in the applied aspects of technology they fit within the use-inspired basic research quadrant, also known as

[70] There are a few notable exceptions, such as the case of AT&T's famous Bell Labs. The research team at Bell Labs developed a significant body of applied and basic research that eventually yielded some break-through innovations and major contributions to science. Eight Nobel Prizes were awarded for work completed at Bell Labs. *See* Robert Buderi, *Bell Labs is Dead, Long Live Bell Labs*, MIT TECH. REV. (Sept. 1 1998), https://www.technologyreview.com/s/400241/bell-labs-is-dead-long-live-bell-labs/ [https://perma.cc/M34A-EJL2].

[71] MERTON, *supra* note 51.

[72] Charles A. Garris Jr., *The U.S. Patent System: An Essential Role in Engineering Design Education*, 90 J. ENGINEERING EDUC. 509, 521 (2001).

[73] *See* David Blumenthal et al., *Participation of Life-Science Faculty in Research Relationships with Industry*, 335 NEW ENG. J. MED. 1734, 1738 (1996).

[74] DONALD E. STOKES, PASTEUR'S QUADRANT—BASIC SCIENCE AND TECHNOLOGICAL INNOVATION 72 (1997).

Pascal's quadrant. Lastly, if an inventor does not have a quest for basic understanding and is solely motivated by the applied aspects of technology they fit within the pure applied research, also known as Edison's quadrant. Most academic inventors prefer to pursue research within Bohr's quadrant, which prioritizes the quest for basic understanding and minimizes practical use considerations. Industry, on the other hand, typically hires and rewards researchers who prioritize use considerations, or those who fall within Edison's quadrant.[75]

Figure 1. The Stokes Classification of Research

		Considerations of Use?	
		No	Yes
Quest for Basic Understanding?	Yes	Pure Basic Research (Bohr)	Use-Inspired Basic Research (Pascal)
	No		Pure Applied Research (Edison)

An academic inventor who collaborates with a university to achieve a successful technology transfer event such as patent licensing would likely fit within Pascal's quadrant since they will pursue a combination of basic and applied research. TTOs often struggle to find and sustain the conditions that nurture the type of academic researcher who fits within Pascal's research quadrant.[76]

[75] Even within the quadrants there is variance among inventors. For example, some highly innovative companies like Google seek out "T-shaped" engineers who have deep levels of expertise within a narrow domain and broad general knowledge across multiple domains. This is viewed as an indicator of curiosity, out-of-the-box thinking and the potential to develop breakthrough innovations. *See* JOE TRANQUILLO, AM. SOC'Y FOR ENGINEERING EDUC., THE T-SHAPED ENGINEER: CONNECTING THE STEM TO THE TOP 11 (June 2013).

[76] *See* Vinit Nijhawan, *Maximize Collisions, Minimize Friction: Applying Platform Strategies to Accelerate University Research Commercialization*, 19 TECH. & INNOVATION 415, 416 (2017).

Industry's approach towards knowledge-based rights differ from academia. In industry, knowledge is commoditized and protected as property to restrict knowledge dissipation and protect costly investments in research and development.[77] Free-riding and imitation by rivals is viewed as a major threat that prevents firms from achieving competitive advantage.[78] Industry, therefore, relies to a great extent on various property, contract, and litigation mechanisms to appropriate knowledge for private advantage.[79] Trade secrets, patents, know-how, copyrights, designs, and trademarks are used increasingly by firms to protect knowledge-based assets.[80] Contracts such as non-disclosure, non-solicitation, and non-compete agreements are also used to expand the protection of these knowledge-based rights.[81] Patent litigation in the commercial sector has also risen dramatically in the past few years.[82]

Industry's approach clashes with the open science norms favored by academia. Universities today, however, seek to obtain trademark and patent rights more so than in the past.[83] Their aims, however, are still primarily to serve the public.[84] Restrictive knowledge contracts such as non-competes are, therefore, relatively rare in academia. Industry support of academic invention is encouraged, although it may lead to conflicts since the research findings may be constrained by contractual devices such as confidentiality agreements.[85]

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[77] *See* Norman D. Bishara & David Orozco, *Using the Resource-Based Theory to Determine Covenant Not to Compete Legitimacy*, 87 IND. LAW. J. 979, 979 (2012).

[78] *See* Jay Barney, *Firm Resources and Sustained Competitive Advantage*, 17 J. MGMT. 99, 103–05 (1991). *See generally* MICHAEL E. PORTER, COMPETITIVE STRATEGY (1980).

[79] Bishara & Orozco, *supra* note 77, at 996.

[80] *See generally* DAVID J. TEECE, MANAGING INTELLECTUAL CAPITAL: ORGANIZATIONAL, STRATEGIC AND POLICY DIMENSIONS (2002).

[81] Bishara & Orozco, *supra* note 77, at 988.

[82] *See* James Bessen & Michael J. Meurer, *The Patent Litigation Explosion*, 45 LOY. U. CHI. L.J. 401, 402 (2013).

[83] Jacob H. Rooksby, *University TM: Trademark Rights Accretion in Higher Education*, 27 HARV. J. LAW & TECH. 349, 349 (2014).

[84] James K. Woodell & Tobin L. Smith, *Technology Transfer for All the Right Reasons*, 18 TECH. & INNOV. 295, 300 (2017).

[85] Hakim, *supra* note 29.

Universities may not be financially motivated, yet they face increasing pressure to demonstrate that they are good stewards of scarce research funding awarded by state agencies, private industry grants, donations, and legislative appropriations. The competition for scarce funding and reduced appropriations for state universities has invariably forced universities to find ways to invest in research that yields measurable benefits to society and provides a financial return to the university. For example, in Florida, a metric the legislature uses to determine university funding includes the number of patents awarded every year to state universities.[86] Given the considerable financial rewards that can accrue from patent licensing, university administrators view technology transfer as a lucrative source of funding that also yields prestige.[87] That explains, to some degree, the dramatic rise in patenting and commercialization efforts at universities, as discussed in the next section.

IV. UNIVERSITY TTOS AS COMMERCIALIZATION AGENTS

Universities responded to the Bayh-Dole Act by establishing TTOs to commercialize university inventions. This part examines the practices, differential groupings of leaders and laggards, and the growth related to the activities of these specialized on-campus units.

A. The Goals and Organizational Structures of TTOs and Research Foundations

The mission of most TTOs is to broadly support the university's research efforts rather than a narrow commercialization focus. According to a former TTO director, the central mission of the TTO he helped launch in 1987 was to advance three interrelated goals.[88] First, since the federal government sponsored considerable sums for research, he viewed it as an obligation to translate that research into

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[86] FLA. STAT. § 1001.7065 (2017) ("The following academic and research excellence standards are established for the preeminent state research universities program . . . [o]ne hundred or more total patents awarded by the United States Patent and Trademark Office for the most recent 3-year period.").

[87] Woodell & Smith, *supra* note 84, at 295–96.

[88] Telephone Interview with Dr. Michael Devine, Former Dir. of Tech. Commercialization, Fla. St. U. (Oct. 2, 2017).

inventions that could benefit society.[89] In his view, the TTO office could play an integral role since it could incentivize the academic inventor to that end.[90] Second, technology commercialization could generate novel and additional research inquiries that the academic inventor did not initially realize.[91] Third, funds generated from technology transfer could be applied to support additional research activities within the university.[92]

Prior to the Bayh-Dole Act, universities seldom managed their patenting and licensing activities in-house.[93] Instead, they outsourced this activity to independent foundations or holding companies to avoid the criticism and litigation that might arise from managing patents for financial gain.[94] The prevailing cultural norm in academia was to view the practice of patenting and licensing university research as an unethical activity.[95]

According to one TTO director, separate research foundations help to alleviate concerns since they create a distance between the university and the research foundation as the patent owner.[96] This is particularly true at state universities, which benefit from having a separate legal entity to bypass state regulations that could impede or delay equity investments in startups and financing projects such as infrastructure or capital improvements.[97] The pioneer in this regard was the University of Wisconsin, which created the Wisconsin

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[89] *Id*. According to one estimate, the federal government spent forty billion dollars in 2014 to support research at universities, hospitals and research institutions. ASS'N OF UNIV. TECH. MANAGERS, AUTM LICENSING SURVEY (2014).

[90] Telephone Interview with Dr. Michael Devine, *supra* note 88.

[91] *Id*.

[92] *Id*.

[93] MOWERY ET AL., *supra* note 16, at 38.

[94] *Id*. Some universities clearly are not deterred by the public criticism they may engender for aggressively litigating patent rights. WARF at the University of Wisconsin and Carnegie Mellon have recently been in the spotlight for their aggressive patent litigation tactics and the substantial windfalls these have generated.

[95] JOSEPH ROSSMAN, AM. ASS'N FOR ADVANCEMENT OF SCI., THE PROTECTION BY PATENTS OF SCIENTIFIC DISCOVERIES 8 (1934).

[96] Telephone Interview with Brent Edington, Dir. of Tech. Commercialization, Fla. St. U. (Nov. 21, 2017).

[97] PALMER, *supra* note 12, at 46.

Alumni Research Foundation (WARF) in the 1920s to commercialize academic inventions related to a method for increasing the content of vitamin D in food.[98] To this day, the organizational model WARF pioneered has been replicated across various universities.[99]

Following the model pioneered by WARF, university research foundations are structured as separate legal entities, typically non-profit corporations, charged by their corporate charters to broadly support university research.[100] Although research foundations are separate legal entities, their oversight can include representation from high-ranking university administrators.[101] In the case of the more successful programs, the boards of these foundations comprise

[98] Apple, *supra* note 53, at 390.

[99] *Id*.

[100] For example, the Florida State University Research Foundation's articles of incorporation describes its purpose as:

This corporation is organized and shall be operated exclusively for scientific and educational purposes and not for pecuniary profit. The corporation shall be operated exclusively for the benefit of The Florida State University. The Corporation is a university direct-support organization within the definition of Section 240.299, Florida Statutes, and as such is organized and operated exclusively to receive, hold, invest, and administer property and to make expenditures to or for the benefit of The Florida State University or for the benefit of a research and development authority affiliated with The Florida State University and organized under Part V of Chapter 159 of Florida Statutes. The purposes of this corporation include the promotion and encouragement of, and assistance to, the research and training activities of faculty, staff, and students of The Florida State University through income from contracts, grants, and other sources, including, but not limited to, income derived from or related to the development and commercialization of University work products. The corporation shall provide means by which discoveries, inventions, processes, and work products of faculty, staff, and students of the University may be patented, developed, applied, and utilized in order that the results of such research shall be made available to the public and that funds be made available from such discoveries, inventions, processes, and work products for further research at The Florida State University.

Articles of Incorporation of the Florida State University Research Foundation, Inc., Art. III, https://www.research.fsu.edu/media/1556/articles-of-incorporation-as-amended-by-bod-2-16-00-bor-5-17-00.pdf [https://perma.cc/W6M5-TLL5].

[101] *Id.* at Art. VII (stating the university president, vice-president for research, provost, and dean of arts and sciences must be on the board of the research foundation).

successful individuals and alumni with expertise in the areas of investments, technology, and business administration.[102] University research foundations hold legal title to university-created intellectual property, sign license agreements as the licensors, financially manage the funds associated with royalties, manage equity investments in university-related start-ups, finance university capital spending projects, and administer private research grants.[103] They also develop policies for disbursing funds generated from these activities back to the university to support additional research-related goals and activities. The individuals who manage and generate patent commercialization opportunities, however, generally reside within distinct organizational units known as TTOs.[104]

B. The Process of University Technology Transfer

This section offers an overview and analytical break-down of the major steps and actors involved in a technology transfer event. The key university technology transfer mechanisms involve licensing agreements with private firms and university-based start-ups.[105]

The process begins when an academic inventor such as a doctoral student or professor fills out an invention disclosure form if they believe they have developed a technology that has commercial viability.[106] The TTO reviews these forms and screens them to assess which ones have the greatest potential for success. Typically, if the university passes on the invention, the rights belong

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[102] For example, the WARF Board of Trustees is largely comprised of alumni who have achieved distinction in business. WISCONSIN ALUMNI RESEARCH FOUNDATION BOARD OF TRUSTEES, https://www.warf.org/about-us/board-of-trustees/board-of-trustees.cmsx [https://perma.cc/9KTM-3QGS] (last visited Sept. 15, 2019).

[103] PALMER, *supra* note 12, at 46.

[104] *See* Janet Bercovitz & Maryann Feldman, *Academic Entrepreneurs: Organizational Change at the Individual Level*, 19 ORG. SCI. 69, 70 (2008) (discussing how the invention disclosure process begins when a faculty member consults with the TTO).

[105] Phillip H. Phan & Donald S. Siegel, *The Effectiveness of University Technology Transfer: Lessons Learned, Managerial and Policy Implications, and the Road Forward*, SSRN ELECTRONIC J. 3 (Apr. 2006).

[106] *See* Bercovitz & Feldman, *supra* note 104, at 70.

to the inventor to independently pursue patenting or commercialization.[107]

If the TTO believes the invention disclosure has commercialization potential they will finance the patenting process. Typically, university policies for inventions allocate a significant royalty to the academic inventor that is preset by the employment contract. At the author's institution, an academic inventor receives 40 percent of royalties, which is in line with other research-intensive universities.[108] During, or after the patenting stage, the TTO will attempt to market the technology and find a suitable licensee or commercialization partner. If a suitable partner is found, a licensing agreement is drafted and negotiated that includes an initial term sheet with the most important negotiated items.[109] Following these negotiations, a fully executed license agreement will then be signed by the university, typically the university research foundation, as the licensor.

In some circumstances, a start-up entity called a spin-off will be created for the sole purpose of commercializing the technology.[110] In these cases, it may be that the academic inventor takes on a leadership or consulting role within the new start-up enterprise.[111] These steps are identified as a process flow diagram below in Figure 2.

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[107] The policies at many universities allow the university to release the patent rights to the academic inventor. For example, at Florida State University the university may waive its rights to the invention. *See* FLORIDA STATE UNIV. – OFFICE OF COMMERCIALIZATION, FLORIDA STATE UNIVERSITY INVENTION DISCLOSURE FORM 4, https://www.research.fsu.edu/media/4783/invention-disclosure-form-blank.pdf.

[108] COLLECTIVE BARGAINING AGREEMENT: THE FLORIDA STATE UNIVERSITY BOARD OF TRUSTEES AND THE UNITED FACULTY OF FLORIDA GENERAL FACULTY BARGAINING UNIT 2016–2019 1, 79 (2016).

[109] *See* Valdimir Drozdoff & Darly Fairbairn, *Licensing Biotech Intellectual Property in University-Industry Partnerships*, 2015 COLD SPRING HARBOR PERSP. MED. 1, 4–6 (2015).

[110] SCOTT SHANE, ACADEMIC ENTREPRENEURSHIP 173 (2004) (stating that 14 percent of the time, new ventures are created to exploit university intellectual property and that it is important to note that university spinoff companies are atypical examples of start-up companies).

[111] *Id*. at 151–164.

Figure 2.

C. Internal TTO Challenges

As discussed above, TTOs face significant challenges due to academia's open science norms.[112] The following constraints create additional hurdles for TTOs.

1. Weak Incentives and Human Capital Deficits

Patents can yield strong exclusionary property rights to the owner.[113] The incentives offered to the TTO staff, however, are generally quite weak. This is particularly true of programs that fall outside of the leader programs.[114] For example, licensing managers at most TTOs share no financial reward in the exploitation of patents through licensing. According to one TTO director, very few TTOs have a bonus system for their employees.[115] The main financial benefits accrue to the university and the academic inventor through royalties. In industry, on the other hand, inventors and managers often obtain bonuses and promotions for patents that yield commercialization.[116]

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[112] *See, e.g.*, Fabrizio & Di Minin, *supra* note 27.

[113] Ayres & Ouellete, *supra* note 8, at 281 (discussing the social costs of patents that offer market power).

[114] For example, a public record search revealed that the annual salary of David Day, former TTO Director at the University of Florida (an AAU member institution and a leader TTO) totaled $285,022. This compares the $109,191 yearly salary of the TTO Director at Florida State University (not an AAU member institution and a laggard TTO). Florida Has a Right to Know, *Florida State University System Employee Salaries*, https://prod.flbog.net:4445/pls/apex/f?p=140:1 [https://perma.cc/ECK5-DF2Q].

[115] Telephone Interview with Brent Edington, *supra* note 96.

[116] Donal O'Connell, Inside the Patent Factory – The Essential Reference for Effective and Efficient Management of Patent Creation 106 (2008).

Weak incentives within organizations create a human capital deficit.[117] Under classical economic theory, rational agents seek to maximize their utility.[118] Accordingly, the more talented and entrepreneurial licensing managers will seek greater financial rewards and employment elsewhere, likely in private industry or within leader TTOs. Thus, weak incentives often result in laggard institution TTOs with human capital deficits and that function bureaucratically rather than entrepreneurially.[119]

The staff at laggard TTOs are mainly comprised of attorneys who emphasize legal processes and formalities centered around patenting rather than the deal-making or value creation process.[120] Many of these attorneys also lack business or entrepreneurial experience.[121] The management of patents for commercialization and strategic advantage, however, requires a very different skill set that is more attuned to entrepreneurialism, technology marketing, and negotiations.[122] According to one scholar, "TTOs should augment their legal expertise with persons possessing marketing, development, and entrepreneurial experience who can help develop long-term relationships with commercial partners and mediate potential conflicts."[123]

Several internal characteristics of TTOs impact the likelihood of developing a pipeline and trajectory of successful licensing. For example, researchers have measured the business and marketing expertise of TTO personnel as a determinant of technology transfer

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[117] *See* Michael A. Hitt et al., *Direct and Moderating Effects of Human Capital on Strategy and Performance in Professional Service Firms: A Resource-Based Perspective*, 44 ACAD. MGMT. J. 13, 13–28 (2001) (discussing how human capital is expensive for firms to maintain).

[118] James H. Davis, F. David Schoorman & Lex Donaldson, *Toward a Stewardship Theory of Management*, 22 ACAD. MGMT. REV. 20, 22 (1997).

[119] According to one TTO director, many TTOs are bureaucratic versus entrepreneurial. Telephone Interview with Brent Edington, *supra* note 96.

[120] Osenga, *supra* note 19, at 428.

[121] *Id*. at 425–26.

[122] *E.g.*, Gary P. Pisano & David J. Teece, *How to Capture Value from Innovation: Shaping Intellectual Property and Industry Architecture*, 50 CAL MGMT. REV. 278, 282–83 (2007); Markus Reitzig, *How Executives Can Enhance IP Strategy and Performance*, 49 MIT SLOAN MGMT. REV. 37, 38–43 (2007).

[123] Lee, *supra* note 49, at 1562.

success and found a positive correlation.[124] Stanford, for example, is a leader institution and has a very successful track record of commercializing university research.[125] Stanford adopted a unique model with respect to the internal staffing capabilities of its TTO. According to one source, the genesis of Stanford's unique model originated with Niels Reimers, the founder of its TTO in 1968.[126] Reimers' unique approach focused on marketing and business development rather than on the administrative and legal formalities of patenting.[127] He staffed his TTO with individuals skilled in technology evaluation and marketing rather than the attorneys that traditionally staff the TTOs at most laggard institutions.[128] Stanford's former President John Hennessey noted that the university's success in technology transfer resulted from its technology transfer office's willingness to take risks and to move technology quickly from the lab to the marketplace as opposed to narrowly focusing on drafting licensing arrangements aimed at maximizing royalty revenue.[129]

2. *The Absence of Complementary Assets and Capabilities*

TTOs lack the traditional strategic complementary assets that companies possess such as logistics, manufacturing, sales, marketing, and distribution.[130] Private research and development (R&D) is integrated into an existing value ecosystem that tailors inventions within that system.[131] This results in internal intellectual

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[124] *Id.*; *see also* Andy Locket & Mike Wright, *Resources, Capabilities, Risk Capital and the Creation of University Spin-Out Companies*, 34 RES. POL'Y 1043–57 (2005); Donald S. Siegel et al., *Assessing the Impact of Organizational Practices on the Relative Productivity of University Technology Transfer Offices: An Exploratory Study*, 32 RES. POL'Y 27–48 (2003).

[125] MOWERY ET AL., *supra* note 16, at 45.

[126] *Id.*

[127] *Id.*

[128] *Id.*

[129] Woodell & Smith, *supra* note 84, at 297.

[130] David J. Teece, *Profiting from Technological Innovation: Implications for Integration, Collaboration, Licensing and Public Policy*, 15 RES. POL'Y 285, 288–90 (discussing the various strategic complementary assets required to profit from innovation).

[131] *See* Shane, *supra* note 48, at 130–31 ("Universities differ from private firms in the ways in which they can appropriate private economic returns from the

property management and strategic decision-making capabilities that enable companies to focus on the commercial aspects of R&D within a company's business model.[132] This leads to activities such as: joint ventures, patent continuations, strategic patent landscaping, patent fencing, patent acquisitions, and cross-licenses to extract value from patenting.[133] Universities, on the other hand, often have to rely on an external licensee to locate the business opportunity or "white space" and refine the technology to reach its full commercial potential.[134] As stated by one TTO director "[w]e don't know what's going to be a success. The companies are responsible for product development and distribution."[135] The inability to tailor R&D investments to an existing value ecosystem places TTOs in a difficult situation since they must convince partners in industry of the largely uncertain and unproven merits of university technologies.[136]

D. University TTO Leaders

When one looks at the aggregate licensing statistics, the argument can be made that the Bayh-Dole Act increased social welfare if the assumption holds true that these licenses would not have been executed without patent rights to spur commercialization. For example, one study provided by the Association of University Technology Managers (AUTM) estimates that yearly licenses total nearly eight thousand and amount to $2.7 billion a year in royalty revenues.[137] A large portion of those royalties, however, are derived from a few sizeable inventions at a handful of academic institutions.

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invention of new technology. Universities do not manufacture goods or provide services other than education, making it difficult for them to profit financially from inventions that must be incorporated into products or services before they can be sold.").

[132] Ashish Arora & Marco Ceccagnoli, *Patent Protection, Complementary Assets, and Firms' Incentives for Technology Licensing*, 52 MGMT. SCI. 293, 293–308 (2006).

[133] *See* Robert C. Bird & David Orozco, *Finding the Right Corporate Legal Strategy*, 56 MIT SLOAN MGMT. REV. 81, 81–90 (2014).

[134] Telephone Interview with Dr. Michael Devine, *supra* note 88.

[135] Telephone Interview with Brent Edington, *supra* note 96.

[136] Shane, *supra* note 48, at 130.

[137] ASS'N OF UNIV. TECH. MANAGERS, AUTM LICENSING SURVEY (2010).

The concentration is largely the effect of a few blockbuster cases. For example, in 2010 the top fifteen university TTOs generated 52% of all the licensing revenues among 155 universities sampled.[138] Tables 1 and 2 identify the fifteen highest earning university TTOs in 2010 and 2014.

Table 1. Top Fifteen TTO programs in 2010[139]

1. Northwestern University	$180 million
2. New York University	$178 million
3. Columbia University	$147 million
4. University of California System	$104 million
5. Wake Forest University	$86 million
6. University of Minnesota	$84 million
7. Massachusetts Institute of Technology	$69 million
8. University of Washington	$69 million
9. Stanford University	$65 million
10. Wisconsin Alumni Research Foundation	$54 million
11. California Institute of Technology	$52 million
12. University of Rochester	$42 million
13. University of Massachusetts	$40 million
14. University of Michigan	$40 million
15. University of Texas System	$38 million

[138] *Id.*
[139] *Id.* Data compiled by the author from this source.

Table 2. Top Fifteen TTO programs in 2014[140]

1. New York University	$211 million
2. Columbia University	$164 million
3. Princeton University	$135 million
4. University of Washington	$96 million
5. University of California System	$74 million
6. Stanford University	$72 million
7. Massachusetts Institute of Technology	$40 million
8. Wisconsin Alumni Research Foundation	$38 million
9. University of Texas System	$32 million
10. University of Florida	$29 million
11. University of Massachusetts	$28 million
12. University of Illinois Chicago	$27 million
13. University of Pittsburgh	$27 million
14. Duke University	$25 million
15. University of Rochester	$22 million

From a purely financial perspective, successful TTOs are those that consistently show profitability. These TTOs have been described as belonging to a select club.[141] For purposes of this study, leader TTOs are defined as the universities that have reached the top twenty in licensing revenue at least five times during the most recent ten-year reporting period. Everyone else is referred to as a laggard institution. The leaders according to this definition are listed in Table 3.

140 ASS'N OF UNIV. TECH. MANAGERS, AUTM LICENSING SURVEY (2014). Data compiled by the author from this source.

141 VALDIVIA, *supra* note 6, at 6.

Table 3. The Leader Institutions

New York University
Columbia University
Massachusetts Institute of Technology
Northwestern University
University of California System
University of Washington
Stanford University
University of Massachusetts
University of Minnesota
University of Wisconsin
University of Rochester
University of Utah
University of Florida
University of Colorado
California Institute of Technology
Emory University
University of Michigan
Harvard University
University of Iowa
Wake Forest University

Several successful TTO programs are not included in the leader category since they were included in a top twenty grouping due to a rare blockbuster event. This can skew the results and mask the fact that the program is not sustainable over the long term.[142] To avoid this over-inclusive sampling bias, a program has to have a greater than fifty percent chance of being listed in the top twenty ranking within the past ten years. The leaders are thus programs that continually run successful TTO programs and do not rely on the rare and infrequent blockbuster event.

V. TTO BEHAVIOR EXPLAINED

This part offers a theoretical justification to explain why laggard institutions engage in technology transfer if it is so costly and the payoffs are so uncertain. The Bayh-Dole Act encouraged a dramatic increase in university patenting. The sponsors of that statute did not contemplate, however, that most of this patenting activity would yield losses for the vast majority of universities. On the surface, university patenting resembles a lottery, which from an economic standpoint is irrational behavior.[143] The justification for maintaining a TTO does not exist if technology transfer is viewed solely in terms of revenues versus costs. Instead, laggard TTOs are influenced by signaling, social pressures explained by institutional theory, the expected value of achieving a blockbuster technology transfer event and positive spillover effects.

A. Transaction Cost Economics

Under the classic make-or-buy scenario, established transaction cost economics theory suggests that if transaction costs are high, universities will not contract with third parties and will buy or insource patent commercialization activities.[144] Transaction costs in the TTO context include title, search, and enforcement costs. Title costs were substantially decreased after the Bayh-Dole Act since

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[142] *See infra* pp. 31–38. For example, Florida State University was ranked in the top twenty a few years due to the major success of Taxol; however, this proved to be a rare event.

[143] Edward J. McCaffery, *Why People Play Lotteries and Why It Matters*, 1994 WIS. L. REV. 71, 75–79 (1994).

[144] *Id.*; Oliver E. Williamson, *Transaction-Cost Economics: The Governance of Contractual Relations*, 22 J.L. & ECON. 233, 234 (1979); Oren Bar-Gill & Gideon Parchomovsky, *Law and the Boundaries of Technology-Intensive Firms*, 157 U. PA. L. REV. 1649, 1661 (2009).

that Act clarified ownership and licensing of university-related patents.[145] Search costs include the costs of finding appropriate inventions, that is, academic inventors who provide promising invention disclosures and suitable licensees who will commercialize the technology. In many respects, TTO offices function as matchmakers between academic inventors and commercial enterprises. Enforcement costs relate to policing a licensee's compliance through royalty audits and the pursuit of litigation in cases where an infringer refuses to pay a license.

Litigation costs are not prohibitive since they are largely a function of attorney's fees and are well-known in advance. The American Intellectual Property Law Association (AIPLA) surveys patent-related litigation costs every year.[146] Although patent litigation is an expensive process, the costs are well-defined *a priori* and rational economic decisions can be made in relation to whether it is efficient to pursue litigation against infringers.[147] Since title and

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[145] *See* Lee, *supra* note 49, at 1512 ("As a general matter, one could characterize the Bayh-Dole Act and the rise of university patenting as attempts to facilitate market-based transfer of academic technologies to the private sector for commercialization."); Peter Mikhail, *Hopkins v. CellPro: An Illustration that Patenting and Exclusive Licensing of Fundamental Science is Not Always in the Public Interest*, 13 HARV. J.L. & TECH. 375, 378 (2000) ("Until the passage of the Act, universities were forced to deal with a myriad of different policies regarding research funding and ownership of inventions. In total, twenty-six different agency regulations existed, all of them presumptively granting the government title to federally funded inventions. It was difficult, time-consuming, and risky for universities to overcome the presumptions of federal title.").

[146] Proceeding to a jury verdict is notoriously expensive. For example, according to the American Intellectual Property Law Association (AIPLA), the average cost of a jury trial for a patent infringement lawsuit ranges between $970,000 and $5.9 million, depending on the amount of damages at stake. *2013 Report of the Economic Survey*, AM. INTELL. PROP. L. ASS'N (2013), https://www.aipla.org/detail/journal-issue/2013-report-of-the-economic-survey [https://perma.cc/B373-NJXX].

[147] For example, the market for financing commercial litigation in general has evolved into a highly specialized and sophisticated specialty area of finance. *See* Maya Steinitz, *The Litigation Finance Contract*, 54 WM. & MARY L. REV. 455, 460–61 (2012) (discussing how litigation financing "relates to the funding of business disputes, such as disputes relating to intellectual property, antitrust, business contracts, and international commercial and investment arbitration brought by sophisticated parties and involving larger stakes").

litigation costs are well-defined and not prohibitively expensive, universities outsource the ownership and litigation of university patents to third parties, namely university research foundations organized as separate legal entities. Search costs, however, remain high and uncertain since universities are in the best position to find the academic inventors who will submit promising invention disclosures and commercial licenses. As predicted by transaction cost economics theory, this function is largely insourced by the university through its TTO.

Transaction cost economics is a useful theory to explain the emergence of TTOs and research foundations since each organizational entity addresses a different aspect of university patenting and the related transaction costs. Although it is a useful theory, transaction cost economics does not explain why laggard institutions continue to engage in technology transfer efforts when on average they sustain considerable losses every year.[148]

B. Institutional Theory and Signaling

Institutional theory explains what seems like irrational behavior incentivized by the Bayh-Dole Act. This theory recognizes that organizations operate within a social framework of norms, values, and assumptions regarding what constitutes acceptable modes of economic behavior.[149] This theory posits that motives of human behavior extend beyond economic optimization to include social justification and social obligation.[150] A central question institutional

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[148] *But see* Lee, *supra* note 49, at 1535. Professor Lee argues that technology transfer is explained by the tacit knowledge that must be transferred between the inventor and the licensee. The relational nature of technology transfer, he argues, explains why so few TTOs are not outsourced but are instead insourced. This is in line with transaction cost economics since the highly personal nature of contracting tacit knowledge increases transaction costs and leads to insourcing. This article agrees with Professor Lee's conclusions; however, it brings to light the institutional theory aspects that help explain why universities sustain TTO-related losses year-after-year.

[149] *See generally* Christine Oliver, *Sustainable Competitive Advantage: Combining Institutional and Resource-Based Views*, 18 STRATEGIC MGMT. J. 697, 697–713 (1997); Bercovitz & Feldman, *supra* note 25, at 181.

[150] STRUCTURES OF CAPITAL: THE SOCIAL ORGANIZATION OF THE ECONOMY 1–37 (Sharon Zukin & Paul DiMaggio eds., 1990).

theorists ask is: 'Why do so many organizations act and look the same?'[151] Institutional isomorphism, or the processes in which organizations resemble one another, helps to explain similarities across institutions.[152] Universities exhibit traits of institutional isomorphism, whereby the laggard organizations mimic the behavior of a select group of leader programs to achieve legitimacy, even if these activities routinely create losses. There are three main types of institutional isomorphism identified in the organizational behavior literature: normative, coercive, and mimetic.[153] Normative isomorphism involves professional standards that result in uniformity.[154] Coercive isomorphism refers to formal and informal pressures that originate from non-professional actors, such as regulators and policymakers.[155] Mimetic isomorphism occurs when organizations mimic others to reduce risk and uncertainty.[156] All three explain the seemingly irrational persistence of TTOs within laggard institutions after the passage of the Bayh-Dole Act.

1. Normative Isomorphism

Laggard TTOs face normative isomorphism due to the aspirational goals reflected within university associations and standards. Since some universities have successful leader TTOs, the argument is laggard universities should likewise have TTOs, if anything just to resemble the elite group they aspire to join. Whereas TTOs, such as WARF, originally emerged from the entrepreneurial efforts of key individuals, university administrators today face pressure from within their professional communities, that is other universities, to normatively adopt these structures.

Normative pressure stems from the fact that most leader universities belong to the prestigious American Association of Universities (AAU). Seventeen of the twenty leader TTOs (85%) listed in Table 3 are housed within universities that belong to the

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[151] Paul J. DiMaggio & Walter W. Powell, *The Iron Cage Revisited: Institutional Isomorphism and Collective Rationality in Organizational Fields*, 48 AM. SOC. REV. 147, 148 (1983).
[152] *Id*. at 149.
[153] *Id*. at 150.
[154] *Id*. at 152.
[155] *Id*. at 150.
[156] *Id*. at 151.

AAU.[157] This group comprises the elite grouping of research universities in the U.S. and Canada and virtually every research-oriented university aspires to join this cadre.[158] The AAU recognizes the impact of technology transfer and takes an active leadership role in this area, disseminating best practices and policy objectives.[159] Universities that seek to belong to this elite group will seek to resemble AAU institutions and will devote significant resources to technology transfer every year, even if these activities are not financially viable.

2. Coercive Isomorphism

TTOs remain prevalent at laggard institutions due to coercive isomorphism.[160] Coercive isomorphism occurs when pressures to persist and conform arise outside of any professional associations.[161] In the case of TTOs, this pressure arises from governmental and regulatory sources. This source of pressure is considerable since the federal government provides $32 billion worth of research funding every year.[162] Federal acts and congressional oversight hearings signal the importance of public accountability through highly visible statements from public officials that favor technology

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[157] All of the universities listed in Table 3 belong to the AAU, except the University of Massachusetts, University of Utah and Wake Forest University. ASS'N OF AM. U., AAU MEMBER U., https://www.aau.edu/sites/default/files/AAU-Files/Who-We-Are/AAU-Member-Universities--Admission-Year.pdf [https://perma.cc/HX93-5RW4].

[158] Membership into the AAU is by invitation-only and the group comprises a select group of elite universities. Membership in the AAU is a great point of distinction and helps to drive rankings. *See* Phyllis V. Larsen, *Academic Reputation: How U.S. News & World Report Survey Respondents Form Perceptions*, 4 CASE INT'L J. EDUC. ADVANCEMENT 155, 159 (2003) (discussing how membership in the AAU helps respondents in a ranking survey to determine the academic reputation of a university).

[159] ASS'N of AM. U., AAU TECH. TRANSFER WORKING GROUP STATEMENT ON MANAGING UNIVERSITY TECHNOLOGY TRANSFER IN THE PUBLIC INTEREST (2015), https://www.aau.edu/key-issues/aau-technology-transfer-working-group-statement-managing-university-technology-transfer [https://perma.cc/AGH3-KWS5].

[160] *See* DiMaggio & Powell, *supra* note 151.

[161] *Id*.

[162] VALDIVIA, *supra* note 6, at 4.

commercialization.[163] Legislation and executive actions signal a preference for the commercialization of research supported with public funds.

The Bayh-Dole Act itself can be viewed as a source of coercive isomorphism since its legislative history and purpose signal the federal government's interest in promoting university technology transfer and commercialization.[164] Universities are thus likely to feel obligated to maintain TTOs to support the goals of this important federal legislation and demonstrate that they are good stewards of federal research funding. Maintaining a TTO is important to ensure adequate levels of federal research funding going forward and their participation in CRADAs with federal agencies such as the National Insitute of Health.

In the case of state universities, legislative pressure may exist if performance funds are tied to metrics that include patenting and technology transfer. For example, in Florida the legislature awards university performance funding and preeminent university classifications based on a variety of metrics, one of which is the amount of patenting.[165]

3. Mimetic Isomorphism

The existence of TTOs can also be impacted by mimetic isomorphism.[166] This third type of pressure arises from uncertainty.[167] Since running a successful technology commercialization program is rare and difficult, the uncertainty levels are high. This uncertainty pressures institutions to imitate

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[163] *See* COUNCIL ON GOVERNMENTAL RELATIONS, THE BAYH-DOLE ACT: A GUIDE TO THE LAW AND IMPLEMENTING REGULATIONS 2 (1999).

[164] *See* Ashley J. Stevens, *The Enactment of Bayh-Dole*, 29 J. TECH. TRANSFER 93, 95 (2004) (describing the statements made by WARF's Howard Bremer in support of the proposed act); *see Government Patent Policies: Institutional Patent Agreements: Hearings Before the Subcomm. on Monopoly & Anticompetitive Activities of the Select Comm. on Small Bus.*, 95th Cong. 373–80 (1978) (statement of Howard W. Bremer, Patent Counsel, Wis. Alumni Res. Found).

[165] *See* FLA. STAT. § 1001.7065 (2017) (stating that a university's attainment of one hundred or more patents during the most recent 3-year period is one of the metrics for establishing academic and research excellence standards).

[166] *See* DiMaggio & Powell, *supra* note 151.

[167] *Id.*

successful programs to reduce risk and "play it safe." This approach, however, is an ineffective short-cut or heuristic since it simplistically assumes that replicating a successful structure will yield success. The result is that many governing university boards ask themselves "[w]hy can't our state university be just like [MIT] or Stanford University and make technology transfer into a profitable operation."[168] As most TTOs demonstrate, however, the act of establishing these offices does not automatically yield success. Mimetic isomorphism can nonetheless be a powerful force. As stated by one TTO director, universities invest in TTOs "to dream big and discover the next [blockbuster]."[169]

C. Expected Value Theory and Positive Spillovers

Universities behave rationally if one considers the expected value of technology transfer. According to one study, the odds of a blockbuster technology transfer event are positively correlated with the size of the university's research budget.[170] The size of the university's research budget is a predictor since more research translates into more invention disclosures. The odds of a blockbuster decrease dramatically, on the other hand, as research budgets decrease.[171] Universities, however, may rationally view technology transfer payoffs from an expected value standpoint. An expected value multiplies the probability of an event, such as a blockbuster patent, times the gains associated with that event.[172] Since the gains of a blockbuster patent can reach billions of dollars, universities will invest in technology transfer even if the odds are fairly low.

Lastly, universities may continue to spend on technology transfer to achieve positive spillovers that are not properly accounted for in a narrowly defined cost-benefit analysis. Some positive spillovers that occur from technology transfer are the ability to strengthen industry and government agency relationships through licensing, improved reputation among key stakeholders such as the

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[168] Woodell & Smith, *supra* note 84, at 297.

[169] Telephone Interview with Brent Edington, *supra* note 96.

[170] VALDIVIA, *supra* note 6, at 11–12.

[171] *Id*.

[172] Paul H. Rubin, *Why Is the Common Law Efficient?*, 6 J. LEGAL STUD. 51, 51–63 (1977).

community and alumni, the creation of spin-offs that may not generate immediate licensing revenues, and the ability to obtain funding from local, state and federal sources to create incubators and research parks.[173]

VI. THE TAXOL CASE

This part provides an empirical perspective of technology transfer through a discussion of a blockbuster technology transfer event at Florida State University (FSU). Although one single case cannot provide conclusive or generalizable findings, this case has high probative value since it involves a research-oriented university with a sizeable research budget that remains in the laggard category despite managing a blockbuster technology-transfer event.[174] The Taxol case at FSU, therefore, provides a lens through which technology transfer can be applied to many laggard organizations with sizable research programs that aspire to develop leader TTO programs. Data from the case includes archival sources, interviews, and print publications.

A. Case Background

Prior to the arrival of FSU's first TTO director Michael Devine in 1987, FSU had only a handful of patents that provided negligible licensing revenues.[175] The university had no formal TTO in place until Devine's arrival and one attorney was on staff to handle the university's entire technology transfer workload.[176] It can be fairly stated that the university had no real antecedents or culture to support technology transfer prior to Devine's arrival. One day a chemistry professor by the name of Dr. Robert Holton arrived at

173 VALDIVIA, *supra* note 6, at 16.

174 FSU is classified as a "R1 Doctoral University" having the highest research activity under the well-known and utilized Carnegie Classification of Institutions of Higher Education. *See Doctoral Universities*, THE CARNEGIE CLASSIFICATION OF INSTITUTIONS OF HIGHER EDUC., http://carnegieclassifications.iu.edu/lookup/srp.php?clq=%7B%22basic2005_ids%22%3A%2215%22%7D&start_page=standard.php&backurl=standard.php&limit=0,50 [https://perma.cc/GW2S-FNDU] (last visited Sept. 22, 2019).

175 A search of patents registered to Florida State University prior to 1987 at uspto.gov yielded only seven results.

176 Telephone Interview with Michael Devine, *supra* note 88.

Devine's office to discuss his patent applications related to the synthesis and partial synthesis of the Taxol molecule that had exhibited promise in cancer treatments.[177]

The FSU Taxol case must be historically assessed in light of the many significant antecedents that led to Dr. Holton's breakthrough inventions. First among these was that in the 1960's a bark derivative from the Pacific Yew tree known as Taxol was discovered.[178] In 1965, Drs. Monroe Wall and Mansukh Wani, located in the Research Triangle area of North Carolina had collaborated with the National Cancer Institute (NCI) to identify K172 as the substance in the Pacific Yew tree with cancer-fighting properties. In 1971, these two scientists published Taxol's molecular structure in the *Journal of the American Chemical Society*.[179]

In 1979, Dr. Susan B. Horwitz of the Albert Einstein Medical College discovered and published the unique mechanisms in Taxol that fight cancer cells in the journal *Nature*.[180] Her astonishing findings related to Taxol's unique anti-cancer fighting properties created strong interest in the academic world. In 1982, Dr. Holton wrote his first Taxol-related paper after receiving tenure at Virginia Tech. Although he had expressed interest in pursuing Taxol-related research during his early years as an academic, he viewed it as too risky for someone who had not yet earned tenure.[181]

In 1985, Dr. Holton followed his wife Dr. Marie Krafft, a rising star in the field of synthetic organic chemistry to FSU.[182] During the years 1984–1998 the Food and Drug Administration (FDA) approved Taxol for Phase 1 and 2 clinical trials in humans. The drug showed promise, however, 240 pounds of the drug would require

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[177] *Id*.

[178] Kim MacQueen, *From Lab to Market*, vol. 6 FLA. ST. U. RES. REV. 5–7 (1995).

[179] *See* Monroe E. Wall et al., *Plant Antitumor Agents. I. The Isolation and Structure of Camptothecin, a Novel Alkaloidal Leukemia and Tumor Inhibitor from Camptotheca Acuminata*, 88 J. AM. CHEMICAL SOC'Y 3888, 3888–90 (1966).

[180] Peter B. Schiff, Jane Fant, & Susan B. Horowitz, *Promotion of Microtubule Assembly In Vitro by Taxol*, 277 NATURE 665, 665–667 (1979).

[181] Frank Stephenson, *A Tale of Taxol*, 45 FLA. ST. U. RES. REV. (2002).

[182] *Id*. at 8.

felling 360,000 Pacific Yew trees. Conservationists voiced opposition to these massive logging efforts and the sustainability of producing the drug was called into question.

In 1988, the NCI had decided it needed to stop procuring Taxol derived from Pacific Yew trees due to its high expense. Dr. Matthew Suffness oversaw the NCI's Taxol program and he contacted Dr. Holton to persuade him to investigate a semi-synthesis to develop Taxol in a lab to ensure adequate low-cost supply. Prior to this important phone call, Holton had been primarily interested in a full synthesis of the Taxol molecule, which was viewed as the academic "Mount Everest" of synthetic chemistry.[183] Like most academic researchers who operate within Bohr's research quadrant, Holton was not interested in the applied commercialization aspects of the much more promising and economically feasible semi-synthesis approach.[184] During that call with Suffness, Holton learned that Taxol would likely become an approved drug.[185] Having learned this, Holton then oriented his research efforts toward the Taxol semi-synthesis.[186]

In 1989, Holton's team developed a cost-effective Taxol semi-synthesis.[187] That year the NCI had signed a cooperative research and development agreement (CRADA) with Bristol-Myers Squibb (BMS), assigning them exclusive rights to commercialize Taxol for anti-cancer therapies.[188] In 1990, BMS then signed an exclusive patent license with FSU to use Dr. Holton's patented inventions related to the Taxol semi-synthesis.[189] In 1993, BMS introduced Taxol to the market and used Dr. Holton's commercially-efficient synthesis method.[190] By 1999, Dr. Holton's lab at FSU had generated nearly 60 patents and just one year later BMS Taxol-related sales

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183 *Id*. at 9.
184 *See supra* text on p. 18.
185 Stephenson, *supra* note 181, at 9–10.
186 *Id*.
187 *Id*.
188 JORDAN GOODMAN & VIVIEN WALSH, THE STORY OF TAXOL – NATURE AND POLITICS IN THE PURSUIT OF AN ANTI-CANCER DRUG 157–59 (2001).
189 MacQueen, *supra* note 178, at 2.
190 Stephenson, *supra* note 181, at 7.

reached $1.6 billion.[191] In total, FSU received nearly $350 million dollars in Taxol-related royalties.[192]

B. Taxol Technology Transfer Success Factors

Findings from this case illustrate that each of the following were important factors that yielded a highly unusual and successful technology transfer event at FSU, a laggard TTO institution.

1. A Problem Looking for a Solution

The Taxol case was unique since the scientific and commercialization challenges were well-defined *a priori*. A semi-synthesis of Taxol was necessary to ensure a reliable and cost-effective supply of the compound.[193] Taxol, as the FDA clinical trials had already demonstrated, evidenced strong promise as an anti-cancer medication.[194] This scenario contrasts with many other academic inventions, which rarely have a clear commercial solution to an identified problem in the marketplace. In many instances, academic inventions are solutions looking for a problem whereas the Taxol case involved the opposite, a problem looking for a solution. This somewhat singular aspect of the Taxol case may help explain why FSU has not achieved anything remotely similar in terms of patent commercialization and why it remains in the laggard TTO category.

2. Depth of Relational Capital with Key External Stakeholders

Another key insight taken from the case is that technology and innovation do not occur in a vacuum.[195] Dr. Holton's Taxol semi-synthesis required deep collaborations with partners within and

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[191] *Id*. at 12.

[192] *See* Leonora LaPeter, *Keep Your Millions, FSU Tells Professor*, TAMPA BAY TIMES (Dec. 25, 2005), http://www.sptimes.com/2005/12/25/State/Keep_your_millions__F.shtml [https://perma.cc/8PKR-PXXZ].

[193] GOODMAN & WALSH, *supra* note 188, at 178.

[194] Stephenson, *supra* note 181, at 7.

[195] *See* Jasjit Singh & Lee Fleming, *Lone Inventors as Sources of Breakthroughs: Myth or Reality?*, 56 MGMT. SCI. 41, 48–49 (2010) (finding empirical evidence that supports the notion that individuals, especially those without affiliation to organizations, are less likely to achieve breakthroughs and more likely to invent particularly poor outcomes).

external to his lab. These external partnerships included the NCI which spent millions of dollars funding his Taxol-related research. External collaborations crossed over into industry with the CRADA executed between the NCI and BMS and also the license agreement executed between FSU and BMS. The lesson is that relationship capital with key external stakeholders in the private and public sectors should be a foundational element of any successful technology transfer strategy.[196] Likewise, the prompting by Suffness at the NCI that motivated Holton to approach the problem from an applied commercialization perspective highlights how external partners can be important information conduits and unexpected motivators. It was Suffness at the NCI who motivated Dr. Holton to shift his research focus and move from Bohr's quadrant to Pascal's quadrant.[197]

3. *The Inspired and Motivated Academic Inventor*

Dr. Holton was initially intrigued by the challenge of achieving a full synthesis of Taxol.[198] That is where his original research passion and drive resided.[199] This emphasis on basic research is characteristic of academic researchers and scientists.[200] Holton was able to cross into the practical dimension of the problem once he was motivated to do so by his momentous phone call with Suffness at the NCI. This process illustrates how he migrated closer into Pascal's quadrant of applied research.[201] Prior to the phone call with Suffness, Holton was skeptical that Taxol could be commercialized as a drug. As Holton recalled, "[Suffness] knew what the story was better than anybody. He said 'Bob, this one's gonna be a drug, and

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[196] This view is supported by Lee, *supra* note 49, at 1522 ("Given the scarcity of potential suitors for university inventions, personal relationships are critical to identifying licensees.").

[197] Stephenson, *supra* note 181, at 9–10.

[198] *Id*. at 9.

[199] *Id.*

[200] *Id.* at 8–10.

[201] *Id.*; *see also* GOODMAN & WALSH, *supra* note 188, at 178 ("Holton agreed in 1988, 'the need to do something of some practical significance, the opportunity to do something that was really needed and happened to be right on my doorstep' caused him to turn his attention towards a commercial practical route to Taxol.").

somebody's gotta figure out how to make it.' After that call, I realized I needed to change my way of thinking."[202]

This suggests that some successful technology transfer activities require deep levels of engagement and commitment from academic inventors. Studies show that tacit knowledge gained from relational forms of governance, for example consulting engagements, are positively associated with successful cases of university technology transfer.[203] Relational engagements such as consulting or technical assistance are more likely to emerge, however, when academic inventors are passionate about the practical dimensions of their research. This passion can emerge from various sources. For Dr. Holton, it was the call from Dr. Suffness urging him to turn a dream into a reality that would result in saving many lives. For Dr. Steenbok, the University of Wisconsin professor, inventor, and co-founder of WARF it was his desire to promote improved nutrition and ensure that his technology would be widely distributed to the public in a safe, ethical, and responsible manner.[204] Passion of this sort that extends beyond the financial rewards of licensing is likely an important motivator to encourage the academic inventor to shift into Pascal's quadrant and work with industry to advance the commercial and socio-ethical aspects of technology.

4. *The Role of Serendipity and Organizational Learning*

An aspect that is often overlooked in technology transfer is the important role of serendipity. According to Mike Devine's recalling of the Taxol case:

> This was serendipity. Bob was the right person at the right time. And I was the right person at the right time to help get this invention licensed, and I respected him. NCI already had the BMS contract [CRADA]. FSU had nothing to do with the fact that it sold a billion dollars a year.[205]

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[202] Stephenson, *supra* note 181, at 10.
[203] Lee, *supra* note 49, at 1551.
[204] Apple, *supra* note 53, at 377.
[205] Telephone Interview with Dr. Michael Devine, *supra* note 88.

Dr. Holton likewise described the Taxol case as a fortunate incident when he stated: "[w]e got lucky that all this money came to us."[206] Serendipity has played an important role in other high-profile university technology commercialization success stories. Northwestern University's blockbuster discovery of pregabalin was later described as a "serendipitous discovery." In that case, the academic inventor "had no idea that one molecule he made would ever be useful for anything."[207]

An appreciation of the role of serendipity introduces a level of realism to technology transfer dialogues and mitigates the misconceived notion that every invention will be a blockbuster, or that the TTO should consistently operate as a profit center. That does not mean that luck alone will dictate results, as if a lottery system were in effect. The Taxol case illustrates that important success factors such as increased research budgets, key external partnerships, and enhanced motivation driving the academic inventor can increase the odds, albeit low, of achieving a blockbuster event.

Serendipity is likely to play a much greater role, however, in laggard institutions that lack extensive research budgets and the path-dependent capabilities of leader institutions.[208] Path dependence has been defined by scholars as a process that includes singular historical events, which may under certain conditions transform themselves into self-reinforcing dynamics that generate lock-in or persistence over time.[209] For example, some of the capabilities that likely contribute to TTO success are effective knowledge management and entrepreneurialism.[210] These unique

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[206] LaPeter, *supra* note 192.

[207] Peter Kotecki, *As Lyrica profits dry up, Northwestern seeks another 'blockbuster' drug*, DAILY NW. (Apr. 10, 2016), https://dailynorthwestern.com/2016/04/10/in-focus/in-focus-as-lyrica-profits-dry-up-northwestern-seeks-another-blockbuster-drug/ [https://perma.cc/AZ6H-QN4Q].

[208] *See* Jörg Sydow et al., *Organizational Path Dependence: Opening the Black Box*, 34 ACAD. MGMT. REV. 689, 689 (2009) (defining path-dependence as self-reinforcing mechanisms, which are likely to lead an organization into a lock-in stage).

[209] *Id.*

[210] *See* Andrew H. Gold et al., *Knowledge Management: An Organizational Capabilities Perspective*, 18 J. MGMT. INFO. SYS. 185 (2001).

capabilities seem to be present due to the efforts of key individuals who succeed in transforming the cultural and intellectual competencies of TTOs. The success of these efforts is retained within leader organizations and persist over time in a path-dependent manner. The lack of learning within FSU's TTO, on the other hand, was apparent since knowledge of the Taxol case was insufficiently maintained within that office. The author, for example, requested the Taxol license agreements between BMS and FSU. No one within the TTO had retained these important documents. An old incomplete draft agreement was eventually retrieved from an off-campus warehouse. This indicates that the TTO has not maintained a data repository related to the most successful TTO event within that organization's history.[211] Lacking this important historical data creates a learning deficit for future TTO negotiations. In essence, the lack of institutional knowledge about that past success of Taxol is indicative of a dearth at FSU of the market-focused, entrepreneurial-spirited TTO culture that characterizes leader institutions.

C. Summary of the Taxol Case Findings

It is tempting to view the Taxol case as further evidence of Bayh-Dole's success. Yet, the evidence indicates that this event was somewhat of an anomaly and that laggard universities are influenced by normative pressures and play a probabilistic game that can sometimes yield positive results from the expected value theory of technology transfer. The institutional pressure for FSU to continue patenting remains high. The university aspires, for example, to the join the elite grouping of AAU-member institutions. Seventeen of the twenty leader TTOs belong to this prestigious association.[212] Also, the Florida Legislature uses patenting as a metric in its yearly performance funding allocations. As the university's research profile and budget increases, it will likely use patent metrics to

[211] The lack of institutional learning and data management presents a barrier to institutional effectiveness. *Id*.

[212] *See supra* Table 3.

signal its commitment to research and to demonstrate the impact its research has on society.[213]

Patenting has generated positive spillovers at the university. As a result of the hundreds of millions of dollars generated by Taxol, the FSU Research Foundation is flush with resources.[214] This helps support university-related projects, such as endowed professorships and capital expenditure projects that involve STEM-based research labs.[215] Yet, to maximize the chances of future success, FSU's TTO will likely have to strengthen its knowledge management practices.

Further empirical studies may demonstrate that the Bayh-Dole Act simply strengthened the hand of universities such as Stanford, MIT, and the University of Wisconsin that already had a path-dependent technology commercialization capability.

VII. POLICY IMPLICATIONS

Overall, the Bayh-Dole Act stimulated university patenting and licensing. Several negative and unintended consequences have emerged in light of the statute, however, that present a problem from a public policy standpoint. These include: A) universities increasingly engaging in predatory behavior that mimics private industry; and B) the disproportionate concentration of wealth and success among leader institutions. If left unmitigated, these negative consequences may threaten to overshadow the success of Bayh-Dole and can trigger calls for legislative reform. Efforts to reform or weaken Bayh-Dole in turn may kill the proverbial goose that lays the golden eggs. This part will address these dangers and offer prescriptive solutions to address them.

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213 *See* Dave Heller, *FSU Ranked Among World's Top Patent-Producing Universities*, FLA. ST. U. NEWS (June 6, 2017), http://news.fsu.edu/news/university-news/2017/06/06/fsu-ranked-among-worlds-top-patent-producing-universities/ [https://perma.cc/3VBJ-6C8B].

214 The FSU Research Foundation's current assets for the fiscal year ended 2017 totaled $143 million. FLORIDA STATE UNIVERSITY RESEARCH FOUNDATION, INC. FINANCIAL STATEMENTS JUNE 30, 2017 AND 2016.

215 *Id.*

A. University Predatory Practices

University administrators are guardians of the broad public-oriented missions of universities. Sometimes, this purpose clashes with the narrower financial interests of privately funded research. For example, in some cases, industry requires secrecy, and this may prevent the academic inventor from sharing their findings with the broader scientific community. There have been troubling instances where industry stifles discussion if the academic findings they have sponsored are contrary to their financial interests.[216] For example, corporate sponsors may stifle debate and disclosure through the use of restrictive confidentiality agreements that prevent academic researchers from speaking about their findings.[217] In some disturbing instances, private parties may litigate or threaten to sue to intimidate and harass academic researchers.[218] Administrators must preserve the unique and open culture of universities and guard against overly-aggressive or predatory patenting and licensing practices even if it means sacrificing short-term financial research commitments or taking a hard stance against corporate sponsors.

The successful commercialization of university inventions has generated unexpected conflicts. For example, universities have increasingly been parties to patent litigation. Recently, state universities have purchased patents from companies and granted exclusive licenses back to those companies. This is done to assert sovereign immunity against parties who seek to challenge the patents in administrative proceedings.[219] This calls into question

[216] *See* Nicolas Bagley et al., *Scientific Trials-In the Laboratories, not the Courts*, JAMA INTERNAL MED. E1–E2 (2017) (discussing several incidences where companies used legal means and the threat of expensive, embarrassing and protracted litigation to stifle or silence academic research findings); David Orozco, *Strategic Legal Bullying*, 13 N.Y.U. J. L. & BUS. 137, 168 (2016) (stating that something similar occurs when "[i]n some cases, companies attempt to restrict consumers from posting truthful reviews online by adding non-disparagement clauses into contracts with customers.").

[217] Hakim, *supra* note 29.

[218] Bagley et al., *supra* note 216.

[219] *See* Dennis Crouch, *Sovereign Immunity Excuses University of Florida from IPR Challenge*, PATENTLY–O BLOG (Feb. 1, 2017), https://patentlyo.com/patent/2017/02/sovereign-university-challenge.html [https://perma.cc/FTZ6-NHP4].

whether state universities should offer their sovereign immunity for sale.[220] In other cases, universities have been derisively labeled patent trolls due to their aggressive patent assertions and litigation postures. For example, in December 2012, Carnegie Mellon University was awarded a $1.17 billion jury verdict in a patent infringement suit against Marvell Technology Group.[221] WARF has likewise drawn criticism due to its aggressive litigation and large patent verdicts. In October 2015, a jury awarded WARF $234 million against Apple, Inc. in a patent lawsuit.[222]

This behavior has led the AAU to issue a report related to universities that litigate patents and recommends several best practices such as restraint, cooperation, and using patents to promote public welfare.[223] The report, for example, advises universities to avoid selling patents to patent trolls and to employ non-exclusive licenses.[224] The AAU's recommendations are sound since Congress may decide, in light of the negative consequences associated with university patenting, to revisit Bayh-Dole or implement other legislation that restricts university technology transfer. All universities, leaders and laggards, should adopt and implement these recommendations as a code of conduct and best practices to be followed by university research foundations and TTOs.

[220] *See* Mark D. Shelley, II et al., *State Sovereignty 101: State Universities not Immune to IPR Proceedings*, NAT'L L. REV. (June 17, 2019), https://www.natlawreview.com/article/state-sovereignty-101-state-universities-not-immune-to-ipr-proceedings [https://perma.cc/ABM3-NYYJ].

[221] Rich Lord, *Carnegie Mellon Wins $1.17 Billion in Patent Case*, PITT. POST-GAZETTE (Dec. 27, 2012), https://www.post-gazette.com/news/education/2012/12/27/Carnegie-Mellon-wins-1-17-billion-in-patent-case/stories/201212270173 [https://perma.cc/YQP6-JJAZ].

[222] *See* Joe Nocera, *The Patent Troll Smokescreen*, N.Y. TIMES (Oct. 23, 2015), https://www.nytimes.com/2015/10/24/opinion/the-patent-troll-smokescreen.html [https://perma.cc/W5NE-RV29] (asking whether WARF is a patent troll).

[223] AAU Working Grp. on Tech. Transfer & Intellectual Prop., *Statement to the AAU Membership on University Technology Transfer and Managing Intellectual Property in the Public Interest*, AUTM (Mar. 2015) https://www.autm.net/AUTMMain/media/Advocacy/Documents/AAU_Working_Group_Managing_University_IP_MAR2015.pdf [https://perma.cc/5RJJ-FVZ5].

[224] *Id.* (recommending universities to establish policies restricting work with so-called patent trolls).

University administrators may also be tempted to treat research as simply a means to achieve commercialization success and much-needed funds. Given its highly uncertain nature, however, it would be risky to view technology transfer as a remedy against falling appropriations or dwindling tuition revenues. If anything, technology transfer should be treated as one element of a much larger strategy that involves funding sources and external stakeholder engagement. According to Mike Devine, FSU's former TTO director, "[i]f the purpose of the TTO is to make money, you're going to be seriously disappointed."[225] University administrators, nonetheless, may be tempted to see TTOs as a means to increase their institutional profiles and endowments in light of a few blockbuster examples.[226]

Another danger facing university administrators is the temptation to place too much emphasis on certain areas of academic research that have an applied commercial focus. For example, a good deal of research in natural sciences consists of basic research, whereas other fields such as medicine naturally favor applied science.[227] It may be tempting for policymakers and university administrators to favor certain disciplines over others in terms of faculty hiring or research funding commitments. This could distort the traditional university model of cooperation and support across departmental units. The danger is real since a university association recently recommended that technology transfer be included within faculty tenure and promotion criteria.[228] This type of short-sighted policy could have drastic and negative consequences for the collaborative spirit of universities and their mission to promote basic research and scholarly inquiry.

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[225] Telephone Interview with Dr. Michael Devine, *supra* note 88.

[226] Woodell & Smith, *supra* note 84, at 297.

[227] MOWERY ET AL., *supra* note 16, at 20.

[228] Colleen Flaherty, *University Group Pushes 'Technology Transfer' in Tenure, Promotion*, INSIDE HIGHER ED (Nov. 17, 2015), https://www.insidehighered.com/quicktakes/2015/11/17/university-group-pushes-technology-transfer-tenure-promotion [https://perma.cc/UVG5-N2FS].

B. Skewed Value Distribution

The skewed distribution of TTO success among leaders is also problematic and contrary to the spirit of Bayh-Dole as a federal act. If left unabated, the public trust in the efficacy of Bayh-Dole may be eroded due to the perception that very few elite institutions with large endowments are the ones benefitting from this statutory scheme at the expense of the public and taxpayer support. It is therefore, incumbent upon leader organizations to share best practices with laggard institutions to disseminate knowledge of ways to capitalize on technology commercialization. Since it appears that leaders have path-dependent capabilities that allow them to continually place within the leader category, there are unique internal practices that yield success and these should be more broadly discussed and disseminated through professional associations and conferences.

For example, some leader TTOs provide incentives to increase their human capital.[229] A more enlightened management approach could also emphasize smaller and medium-sized transactions that generate trust with commercial partners, facilitate learning and increase deal flow. Relying on a blockbuster event is speculative and as the Taxol case demonstrates it does not necessarily promote learning or provide the foundation for future success. A suitable forum for disseminating these best practices may be an organization like AUTM, where TTO managers converge within a professional association. Leader organizations should take a proactive role to diffuse best practices so that more TTOs are at least financially self-sufficient and in a better position to achieve licensing opportunities and success.

The failure to address this concern may spark calls to limit university technology transfer or place a tax on this activity. It is worth noting that the original version of the bill included provisions designed to defuse criticism that it would lead to profiteering at the expense of the public interest. This included a recoupment provision requiring that universities pay back a share of licensing income to funding agencies.[230] The final version of the Bayh-Dole Act

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229 Osenga, *supra* note 19, at 419.
230 Mowery, *supra* note 43.

eliminated this provision since "there was no agreement on whether the funds would be returned to the agencies or to general revenue, or how the collection and auditing functions would be conducted" and "fears that the costs of the infrastructure required to administer such a program would exceed the amounts collected."[231]

VIII. CONCLUSION

Universities are unique environments that thrive on the research activities of faculty and students. A substantial amount of innovation results from the creative endeavors of these individuals. To disseminate knowledge and potentially derive lucrative sources of funding, universities have entered the field of technology commercialization and patenting. The passage of the Bayh-Dole Act was instrumental to encourage this activity and the result has been an explosion of university-related patenting and licensing.

Thirty-nine years have passed since the passage of the Bayh-Dole Act. On the whole, the statute's purpose has been fulfilled regarding the increased rates of patent commercialization of federally-sponsored research at U.S.-based universities.[232] Indeed, the biotechnology industry is largely a product of the statute's success.[233] That is not to say, however, that negative unintended consequences did not arise. Notably, the statute has reified the success at a few elite institutions with path-dependent capabilities and labeled here as leaders in the technology transfer field. Laggard institutions attempt to mimic the leaders' success and institutional theory explains why so many laggards do this despite having low probabilities of achieving success. In some isolated examples, serendipity plays a large role in blockbuster events, such as the case of FSU with its blockbuster Taxol semi-synthesis patents.

Several policy implications arise from the analysis of university-based technology transfer from the perspective of TTOs. First, technology transfer should not be viewed narrowly in terms of

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[231] *Id.*
[232] Kesan, *supra* note 12, at 2178.
[233] Eberle, *supra* note 36.

financial costs and benefits.[234] It is clear that technology transfer yields positive spillovers that extend beyond licensing revenues.[235] For example, technology transfer has an important signaling role since it allows universities to highlight their commitment to research advancement as well as the positive impact of the university's research on society.[236] Second, two major negative and unintended consequences of Bayh-Dole include the increasingly predatory commercial behavior of universities and the skewed value distribution of TTO success. To address these concerns university administrators who are the trustees and gatekeepers of public-oriented institutions must recognize the negative consequences of this behavior and adopt policies that prioritize the public missions of universities. Finally, to address the skewed value distribution, leader TTOs should take a more active role disseminating best practices among laggard TTOs to avoid the perception of unfair and ineffective technology transfer outcomes.

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[234] *See* Kesan, *supra* note 12, at 2188 (stating that "TTOs cannot be justified simply on financial terms").

[235] Osenga, *supra* note 19.

[236] *See* Maryann Feldman et al., *Equity and the Technology Transfer Strategies of American Research Universities*, 48 MGMT. SCI. 105, 108 (2002).