AN EMPIRICAL STUDY OF UNIVERSITY PATENT ACTIVITY

CHRISTOPHER J. RYAN, JR. & BRIAN L. FRYE

ABSTRACT

The United States patent system is in flux. Since 1980, a series of legislative acts and judicial decisions have affected the ownership, scope, and duration of patents. In 1980, the Bayh-Dole Act enabled academic institutions to patent inventions created in relation to federally funded research. In 1994, Congress extended the maximum patent term from 17 years to 20 years. And in 2011, the American Invents Act shifted the patent system from a first to invent standard to a first to file system. These changes impacted academic institutions, both directly and indirectly, and have coincided with historic increases in patent activity among academic institutions.

This article presents an empirical study of how those three changes to the patent system precipitated responses by academic institutions, using spline regression functions to model their patent activity. We find that academic institutions typically reduced patent activity immediately before changes to the patent system, and increased patent activity immediately afterward, with an especially notable effect among research universities. In other words, academic institutions responded to patent incentives in a manner consistent with firm behavior, by reacting to the preferences of internal coalitions to capture unrealized economic value in intellectual property.

The response of academic institutions to patent law changes has profound implications for economic efficiency. Academic institutions are typically charitable organizations, with the charitable purpose of promoting innovation, among other things. Yet, academic institutions have responded to patent incentives by limiting access to innovation, in order to internalize economic value. Specifically, academic institutions typically transfer their patents to patent assertion entities or “patent trolls,” rather than practicing entities, producing externalities and inefficiency in the patent system.

This concern is highlighted by the Supreme Court’s recent grant of certiorari in TC Heartland v. Kraft Foods, in order to determine the scope of patent venue. The Court’s decision was motivated by flagrant “forum selling” in the Eastern District of Texas, which currently hears about 50% of the patent infringement actions filed in the United States, few of which have any connection to the district. Most of the patent infringement actions heard in the Eastern District of Texas are filed by patent assertion entities that choose the forum based on its pro-plaintiff bias. Many observers are concerned that the concentration of patent assertion activity in the Eastern District of Texas has increased the cost of innovation. This study suggests that educational institutions may have exacerbated that problem by engaging more boldly in patent activity and ultimately transferring their patents to patent assertion entities.
AN EMPIRICAL STUDY OF UNIVERSITY PATENT ACTIVITY

Christopher J. Ryan, Jr. & Brian L. Frye*

INTRODUCTION

The United States patent system is in flux. Since 1980, a series of legislative acts and judicial decisions have affected the ownership, scope, and duration of patents. In 1980, the Bayh-Dole Act enabled academic institutions to patent inventions created in relation to federally funded research.¹ In 1994, Congress extended the maximum duration of a United States patent from 17 to 20 years, increasing the monopolistic value of patent protection.² And in 2011, the American Invents Act shifted the patent system from a first to invent standard to a first to file system.³ These changes impacted academic institutions, both directly and indirectly, and have coincided with historic increases in patent activity among academic institutions.

The response of academic institutions to patent law changes has profound implications for economic efficiency. Academic institutions are typically charitable organizations, with the charitable purpose of promoting innovation, among other things. Yet, academic institutions have responded to patent incentives by limiting access to innovation, in order to internalize economic value. Specifically, academic institutions typically transfer their patents to patent assertion entities or “patent trolls,” rather than practicing entities, producing externalities and inefficiency in the patent system.⁴

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This concern is highlighted by the Supreme Court’s recent grant of certiorari in *TC Heartland v. Kraft Foods*, in order to determine the scope of patent venue. The Court’s decision was motivated by flagrant “forum selling” in the Eastern District of Texas, which currently hears about 50% of the patent infringement actions filed in the United States, few of which have any connection to the district. Most of the patent infringement actions heard in the Eastern District of Texas are filed by patent assertion entities that choose the forum based on its pro-plaintiff bias. Many observers are concerned that the concentration of patent assertion activity in the Eastern District of Texas has increased the cost of innovation. This study suggests that educational institutions may have exacerbated that problem by engaging more boldly in patent activity and ultimately transferring their patents to patent assertion entities.

I. THE PATENT SYSTEM

The purpose of the patent system is to promote technological innovation, or rather to “promote the Progress of . . . useful Arts, by securing for limited Times to . . . Inventors the
exclusive Right to their respective . . . Discoveries." While some scholars have questioned the efficiency of the patent system, and other scholars have suggested that it may only provide efficient incentives in some industries, conventional wisdom assumes that it is generally efficient, providing a net public benefit by encouraging investment in innovation. In any case, while the patent system has always provided essentially identical incentives to all inventors in all industries, the demographics of patent applicants and owners have changed over time. Originally, many patent applicants and owners were individual inventors, but for quite some time, the overwhelming majority of patent applicants and owners have been corporations. An increasing number of those corporate patent applicants and owners are academic institutions.

A. Academic Patents

Academics have always pursued patents on their inventions, with varying degrees of success. But academic institutions did not meaningfully enter the patent business until the early 20th century, and even then only tentatively. In 1925, the University of Wisconsin at Madison created the first university patent office, the Wisconsin Alumni Research Foundation, an independent charitable organization created in order to commercialize inventions created by University of Wisconsin professors. Similarly, in 1937, MIT formed an agreement with Research

9 U.S. Const. Art. 1, sec. 8, cl. 8. See also, A Brief History of Patent Law of the United States, Ladas & Parry, http://ladas.com/a-brief-history-of-the-patent-law-of-the-united-states-2/ (last visited April 20, 2016). In this article, the term "patent" is used to refer exclusively to utility patents. While the United States Patent and Trademark Office also issues design patents and plant patents, and the United States Code provides for protection of vessel hull designs and mask works, both of which resemble design patents, all of these forms of intellectual property are outside the scope of this article.


Corporation, an independent charitable organization, to manage its patents.\textsuperscript{13} Many other schools followed MIT’s lead, and Research Corporation soon managed the patent portfolios of most academic institutions.\textsuperscript{14}

Before the Second World War, academic institutions engaged in very limited patent activity, collectively receiving less than 100 patents. But during the war, many academic institutions adopted formal patent policies, typically stating that faculty members must assign any patent rights to the institution.\textsuperscript{15} Gradually, some academic institutions began creating their own patent or “technology-transfer” offices. But by 1980, only 25 academic institutions had created a technology-transfer office, and the Patent Office issued only about 300 patents to academic institutions each year.\textsuperscript{16}

Since then, patent law has increasingly encouraged and been shaped by the patent activity of academic institutions. Until 1980, each federal agency that provided research funding to academic institutions had its own patent policy. Some provided that inventions created in connection with federally funded research belonged to the federal government, others placed them in the public domain, and a few negotiated institutional patent agreements with academic institutions, allowing them to own patents in those inventions. However, in 1980, Congress passed the Bayh-Dole Act, which enabled academic institutions to patent inventions created in connection with federally funded research.\textsuperscript{17} Specifically, the Act provided that, with certain exceptions and limitations, “a small business firm or nonprofit organization” could patent such inventions, if the organization timely notified the government of its intention to patent the

\textsuperscript{13} Research Corporation was formed in 1912 by Professor Frederick Cottrell of the University of California to manage his own inventions, as well as those others submitted by faculty members of other educational institutions. See Frederick Cottrell, The Research Corporation, an Experiment in Public Administration of Patent Rights, JOURNAL OF INDUSTRIAL AND ENGINEERING CHEMISTRY 846-67 (December 1912).

\textsuperscript{14} See Jacob Rooksby, The Branding of the American Mind 130-35 (2016).

\textsuperscript{15} By 1952, 73 universities had adopted a formal patent policy. By 1962, 147 of 359 universities that conducted scientific or technological research had adopted a formal patent policy, but 596 universities reported that they conducted “little or no scientific or technological research” and had no formal patent policy.


invention and gave the government the right to use the invention.\(^{18}\) The Act placed certain additional requirements on nonprofit organizations, providing that they could only assign their patents to an organization having as a primary function the management of inventions, must share any royalties with the inventor, and use their royalties only for research or education. The limitation on assignment was intended to encourage academic institutions to assign their patents to charitable organizations like Research Corporation, but in practice it led many of them to assign their patents to patent aggregators or “patent assertion entities,” which are known pejoratively as “patent trolls.”\(^{19}\)

At about the same time, the scope and duration of patent protection began to expand. First, the Supreme Court explicitly expanded the scope of patentable subject matter to include certain genetically modified organisms and computer software.\(^{20}\) Then, in 1982, Congress created the United States Court of Appeals for the Federal Circuit, with exclusive jurisdiction over patent cases, which adopted consistently pro-patent positions.\(^{21}\) In 1984, Congress expanded the patentability of pharmaceuticals.\(^{22}\) In 1994, Congress extended the maximum duration of a United States patent from 17 to 20 years, increasing the value of a patent.\(^{23}\) And in 2011, Congress amended the Patent Act by, inter alia, moving from a first-to-invent to a first-to-file patent system.\(^{24}\)

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\(^{18}\) 35 U.S.C. § 202(c)(7).


\(^{21}\) See Federal Courts Improvement Act, 96 Stat. 25 (1982) (creating an appellate-level court, the U.S. Court of Appeals for the Federal Circuit, with the jurisdiction to hear patent cases).


All of these changes in patent protection caused an increase in overall patent activity. In 1980, the Patent Office received 104,329 patent applications and granted 61,819 patents. In 1990, it received 164,558 applications and granted 90,365 patents. In 2000, it received 295,926 applications and granted 157,494 patents. And in 2010, it received 490,226 applications and granted 219,614 patents.

Academic institutions played a role in the growth of nationwide patent activity. In response to these policy changes, many universities adopted a research model under which federal grants and other public funds were directed at the development of patentable inventions and discoveries, enabling the universities to obtain patents and claim a private benefit. By 1990, more than 200 academic institutions had created technology-transfer offices, and the Patent Office was issuing more than 1,200 patents to academic institutions each year. Ironically, while some of the patents granted to academic institutions proved extremely valuable, the overwhelming majority of them were worthless. Most of the technology-transfer offices created by academic institutions produce little revenue, and many actually lose money. In addition, they force academic institutions to make uncomfortable decisions about licensing and litigation. Academic institutions are typically charitable organizations with the charitable purpose of generating and disseminating knowledge. But as patent owners, they have a financial incentive to limit the use of the knowledge they generate. Many academic institutions have


26 Id.

27 Id.

28 Id.

29 Id.


responded to this ethical dilemma by assigning their patents to patent assertion entities, in order to obscure their relationship to those patents and avoid the obligation to enforce them.\(^{33}\)

**B. Promoting or Stifling Innovation?**

The prevailing theory of patents is the economic theory, which holds that patents are justified because they solve market failures in innovation caused by free riding. In the absence of patents, inventions are “pure public goods,” because they are perfectly non-rivalrous and non-excludable. Classical economics predicts market failures in public goods, because free riding will prevent marginal inventors from recovering the fixed and opportunity costs of invention.\(^{34}\) Under the economic theory, patents solve market failures in innovation by granting inventors certain exclusive rights in their inventions for a limited period of time, which provide salient incentives to invest in innovation.\(^{35}\)

But patents may also cause market failures by granting inefficient rights to inventors and imposing transaction costs on future inventions.\(^{36}\) In theory, patent law can increase net economic welfare by granting patent rights that are salient to marginal inventors and encourage future inventions. But in practice, patent law may grant rights that are not salient to marginal inventors and discourage future inventions. For example, patent law may cause market failures by discouraging marginal inventors from investing in innovation.

The American patent regime has precipitated “arms race” and “marketplace” paradigms, both of which elicit firm behavior.\(^{37}\) In the first instance, the benefits of patent protection incentivize innovators to aggregate under the auspices of the firm model, thereby reducing the

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\(^{33}\) JACOB ROOKSBY, THE BRANDING OF THE AMERICAN MIND, 150-67


\(^{35}\) See RICHARD POSNER, ECONOMIC ANALYSIS OF LAW §3.3: Intellectual Property, 50 (2007).

\(^{36}\) Because the benefits of patent protection disincentivize the inventor from further innovating the patented invention, patent law can be said to discourage innovation. This is because—from the time the invention is granted a patent—the inventor’s costs are sunk, meaning that the inventor must incur new development costs and secure a new patent in order to innovate under the patent law regime. See id. at 48.

marginal cost to each innovator of producing patentable technology. The marketplace paradigm encourages innovation, or at least innovation likely to result in patent protection. Both paradigms, however, are subject to the results of the perverse incentives that the patent regime provides, specifically that of patent stockpiling and the rent-seeking behaviors of non-practicing and patent assertion entities.  

The right to exclude is perhaps the most important stick in the bundle of patent protection rights and may have the effect of stifling rather than promoting innovation. As the ubiquity of non-practicing and patent assertion entities in the patent market become commonplace, patent holdup, patent litigation, and patent thickets are common features of the modern patent marketplace.

C. University Responses to Policy Incentives

From the perspective of the theoretical literature, innovation depends upon innovators receiving the benefits of their innovation; the regime that allocates these benefits to the innovator and thereby incentivizes innovation is the most efficient. For universities, a majority of which

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38 Id. See also Thomas L. Ewing, Indirect Exploitation of Intellectual Property Rights by Corporations and Investors, 4 HASTINGS SCI. & TECH. L. 1-105 (2011); but see David L. Schwartz & Jay P. Kesan, Analyzing the Role of Non-Practicing Entities in the Patent System, 99 CORNELL L. REV. 425-452 (2014) (arguing that the debate over non-practicing entities should be reframed to focus on the merits of the lawsuits they generate, including patent system changes focusing on reducing transaction costs in patent litigation, instead of focusing solely on whether the patent holder is a non-practicing entity); Holly Forsberg, Diminishing the Attractiveness of Trolling: The Impacts of Recent Judicial Activity on Non-Practicing Entities, 12 PIT. J. TECH. & POL’Y 1-27 (2011) (centering on the difficulties faced by legislators in attempting to solve the patent troll problem and turns to the recent judicial activity related to patent law allowing for individually-focused, closely tailored analysis is examined with an evaluation of four recent court decisions and resulting changes to the patent system).


relied on federal funding to support research and development of patentable innovation during the 20th Century, the patent regime did not substantially encourage universities’ entry into the patent market until the passage of the Bayh-Dole Act in 1980.\textsuperscript{42} Descriptive research in this area suggests that the Bayh-Dole Act—which allowed universities to patent inventions developed in connection with federally-funded research—increased the number of university participants in the patent market.\textsuperscript{43} Some scholars have also attributed university technology transfer and patent title aggregation as being rooted in the Bayh-Dole Act.\textsuperscript{44}


\textsuperscript{44} Jennifer Carter-Johnson, Unveiling the Distinction between the University and Its Academic Researchers: Lessons for Patent Infringement and University Technology Transfer, 12 VANDERBILT J. ENTERTAINMENT & TECH. L. 227 (2010) (exploring the idea that a faculty member acting in the role of an academic researcher in the scientific disciplines should be viewed in the context of patent law as an autonomous entity within the university rather than as an agent of the university, and arguing that acknowledging a distinction between the university and its academic researchers would revile the application of the experimental use exception as a defense to patent infringement for the scientists who drive the innovation economy and encourage academic researchers to participate in transferring new inventions to the private sector); Martin Kenney & Donald Patton, Reconsidering the Bayh-Dole Act and the Current University Invention Ownership Model, 38 RES. POL’y 1407-1422 (2009) (citing the problems with the Bayh-Dole Act’s assignment of intellectual property interests, and suggesting two alternative invention commercialization models: (1) vesting ownership with the inventor, who could choose the commercialization path for the invention, and provide the university an ownership stake in any returns to the invention; and (2) making all inventions immediately publicly available through a public domain strategy or, through a requirement that all inventions be licensed non-exclusively); Liza Vertinsky, Universities as Guardians of Their Inventions, 4 UTAH L. REV. 1949-2022 (2012) (submitting that universities need more “discretion, responsibility, and accountability over the post-discovery development paths for their inventions,” in order to allow the public benefit of the invention to
However, these developments point to the fact that universities may be responding to policy interventions—such as the extension of the duration of patents in 1995 and anticipation of the America Invents Act—and in turn, affect the patent landscape. Examples of these responses include shifting investment in research and development toward innovation sectors that are more likely to receive patent protection, particularly those with high renewal rates, and because the US Patent and Trademark Office (PTO) derives more revenue from these sectors, it has the incentive to grant applications from high renewal rate sectors. Additionally, researchers have noted that the patent regime does not privilege economic development through technological transfer, and may account for both the increase in patent litigation from non-practicing entities, such as universities, as well as rise in rent-seeking behaviors in patent licensing. Moreover, many reach society, and arguing that, because universities guard their inventions, the law should be designed to encourage their responsible involvement in shaping the post-discovery future of their inventions).


46 Kira R. Fabrizio, Opening the Dam or Building Channels: University Patenting and the Use of Public Science in Industrial Innovation, Working Paper, Goizueta School of Business, Emory University (2005) (investigating the relationship between the change in university patenting and changes in firm citation of public science, as well as changes in the pace of knowledge exploitation by firms, measured using changes in the distribution of backward citation lags in industrial patents); Hall, supra note 36 (confirming that growth since 1984 has taken place in all technologies, but not in all industries, being concentrated in the electrical, electronics, computing, and scientific instruments industries); Michael D. Frakes & Melissa F. Wasserman, Does Agency Funding Affect Decisionmaking?: An Empirical Assessment of the PTO’s Granting Patterns, 66 VANDERBILT L. REV. 67-153 (2013) (finding that the PTO is preferentially granting patents on technologies with high renewal rates and patents filed by large entities, as the PTO stands to earn the most revenue by granting additional patents of these types); Tom Coupé, Academic R&D and University Patents, Université Libre de Bruxelles (2010) (finds that more money spent on academic research leads to more university patents, with elasticities that are similar to those found for commercial firms).

47 Clavia Hamilton, University Technology Transfer and Economic Development: Proposed Cooperative Economic Development Agreements Under the Bayh-Dole Act, 36 J. MARSHALL L. REV. 397-421 (2003) (proposing that Congress amend the Bayh-Dole Act to provide guidance on how universities can enter into Cooperative Economic Development Agreements patterned after the Stevenson-Wyler Act’s Cooperative Research and Development Agreements); Lita Nelsen, The Rise of Intellectual Property Protection in the American University, 279 SCIENCE 1460-1461 (1998) (describing the inputs and outcomes of university assertion of intellelctual property rights); Nicola Baldini, Negative Effects of University Patenting: Myths and Grounded Evidence, 75 SCIENTOMETRICS 289-311 (2008) (discussing how the university patenting threatens scientific progress due to increasing disclosure restrictions, changes in the nature of the research (declining patents’ and publications’ quality, skewing research agendas toward commercial priorities, and crowding-out between patents and publications), and diversion of energies from teaching activity and reducing its quality); Mark A. Lemley, Are Universities Patent Trolls?, 18 FORDHAM INTEL. PROP. MEDIA & ENTERTAINMENT L. J. 611-632 (2008) (illustrating that universities are non-practicing entities, sharing some characteristics with trolls but somewhat distinct from trolls, and making the normative argument that the focus should be on the bad acts of all non-practicing entities and the laws that make these acts possible); Jacob H. Rooksby, University Initiation of Patent Infringement Litigation, 10 JOHN MARSHALL REV. INTELL. PROP. L. 623-695 (2011) (revealing similarities between the litigation behavior of universities and for-
universities directly contribute to patent hold-up by transferring patents to patent assertion entities, potentially stifling innovation.\(^{48}\)

**D. Patent Assertion Entities & “Forum Selling”**

The patent activities of educational institutions are troubling not only because they exhibit firm behavior, but also because they may exacerbate other institutional factors that impose costs on innovation. In recent years, it has become quite clear that the United States District Court for the Eastern District of Texas has engaged in a wholesale “forum selling” to patent plaintiffs, by adopting rules and procedures that create a robust pro-plaintiff bias. As a consequence, the Eastern District of Texas is the forum of choice for patent plaintiffs, and is currently hearing about 50% of the patent infringement actions filed in the United States.\(^{49}\) This effect is especially pronounced among patent assertion entities, which have additional flexibility to file actions in the forum of their choice.

In light of concerns about “forum selling” in patent actions, the Supreme Court recently granted certiorari in *TC Heartland v. Kraft Foods*, in order to interpret the scope of patent venue.\(^{50}\) Essentially, the Court will ask whether the patent venue statute provides that venue is proper in any district where the defendant is subject to personal jurisdiction, or only in districts where the defendant is incorporated or actually operates. If the Court adopts the more restrictive interpretation of patent venue, it would prevent the Eastern District of Texas from engaging in forum selling, because few if any patent defendants will have the requisite connection to the

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district.

In any case, because academic institutions have increased their patent activity in response to patent policy incentives and tend to transfer their patents to patent assertion entities, they are likely contributing to the forum-selling problem that the Court is currently addressing. Not only may educational institutions be increasing the cost of innovation by obtaining patents and contributing to patent thickets, but also they may be increasing the cost of innovation by facilitating patent infringement litigation in districts chosen on the basis of their improper pro-plaintiff bias.

E. The University as a Firm

In response to the changes in the patent law system between 1980 and 2011, especially the Bayh-Dole Act, academic institutions increasingly adopted a research funding model under which federal research grants and other public funds were focused on the development of patentable inventions.\(^51\) As previously observed, the total number of patents granted by the Patent Office steadily increased, and so did the percentage of those patents granted to academic institutions.\(^52\) Soon, participants in the patent law system began expressing concerns about “patent trolls,” or entities that decreased the efficiency of the patent system by merely owning and asserting patents, rather than practicing them. Of course, academic institutions that own patents are non-practicing entities almost by definition, as they exist to create and disseminate knowledge, not produce commercial products.\(^53\) Even more troubling, many academic institutions assign most or all of their patents to patent assertion entities, the paradigmatic patent trolls. As a result, the way that academic institutions use patents presents a risk of creating “patent thickets that entangle rather than encourage inventors,” which is in tension with the charitable purpose of those institutions.\(^54\)

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52 See Hall, supra note 36.


54 See RICHARD POSNER, ECONOMIC ANALYSIS OF LAW §3.3: Intellectual Property, 50 (2007). See also Peter Lee, Patents and the University, 63 DUKE L. J. 1 (2013).
But how did these patent thickets sprout from the soil of the university? The behavioral theory of the firm may help explain why academic institutions responded to incentives created by changes in this way. Unlike neoclassical economics, which uses individual actors as the primary unit of analysis, the behavioral theory of the firm uses the firm itself as the primary unit of analysis. As a consequence, the behavioral theory of the firm provides better predictions of firm behavior with regard to output and resource allocation decisions.

The field of organizational economics emerged in 1937, when Ronald Coase observed that firms emerge when the external transaction costs associated with markets exceed the internal transaction costs of the firm.\(^55\) Coase’s theory of the firm was revolutionized in 1963, when Richard Cyert and James March provided a behavioral theory of the firm, observing that firms consist of competing coalitions with different priorities and responding to different incentives.\(^56\)

In the context of funded research, university patent activity can be read as the result of strategic firm decision-making regarding patent output and resource allocation decisions. In fact, the way that patent policy has bent toward rewarding university patent activity through conferral of rights is a direct result of lobbying and decision-making efforts by these universities with lawmakers. The behavioral theory of the firm suggests that academic institutions have responded to incentives created by patent law in a manner consistent with firm behavior.\(^57\) Though heterogeneity of university patent activity does exist, at most intensive research universities, where decisions are made two ways—with executive administrators setting strategic goals for research which are then implemented at lower management levels—intense competition exists between intensive research universities to vie for patent rights and thus profit maximization.

Increasingly, these universities have centralized and ceded title in patents to their foundations and technology transfer offices.\(^58\) As non-practicing entities, universities bear the transaction costs of developing patented inventions, but they transfer the transaction costs of


\(^{58}\) Harold W. Bremer, The First Two Decades of the Bayh-Dole Act, Presentation to the National Association of State Universities and Land Grant Colleges (2001).
bringing the invention to market to intermediaries—and get paid for doing so. As a consequence, the goal of a firm is to “satisfice” rather than maximize results. In other words, firms typically focus on producing “good enough” outcomes, rather than the best possible outcomes, as a function of compromise among internal coalitions with different priorities.

Thus, one could view increased activity immediately after the implementation of a policy conferring greater patent rights not as a random but as a very rational, profit-maximizing response. However, this activity creates a patent thicket because academic institutions are necessarily non-practicing entities with strong incentives to assign their patents to patent assertion entities in order to extract their economic value.

II. Empirical Analysis

A. Research Questions

While academic institutions have responded to patent incentives in a manner consistent with firm behavior, the optimal firm response does not necessarily produce the optimal social outcome. Organizational economics predicts that firms will respond to external incentives by satisficing results consistent with the consensus of internal coalitions. As a consequence, firms may or may not respond to patent incentives in a manner consistent with the patent system’s goal of maximizing innovation. It follows that if academic institutions exhibit firm behavior in relation to patent incentives, they may satisfice internal coalitions at the expense of social welfare.

This study asks whether and how changes in patent law have affected the patent activities of academic institutions. Specifically, it asks two questions:

(1) Did universities change their patent policies in response to changes in patent law?
(2) Did different kinds of universities respond differently to changes in patent law?

To answer these questions, this study analyzes data on the population of academic institutions that were granted one or more patents between 1969 and 2012 in order to determine the impact of policy changes on university patent activity over this time. Notably, this study does not and

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cannot determine whether academic institutions have responded to changes in patent law in a way that increases or decreases net social welfare. But it can help explain how academic institutions have responded to patent incentives and whether their responses are consistent with firm behavior.

B. Data

This study relies primarily on a limited but valuable dataset compiled by the PTO, which records the total number of patents granted per year to each educational institution in the United States between 1969 and 2012. Because of limitations with this data—for example, the data contain only one measured variable, the total number of patents granted to an institution in a calendar year—this dataset had to be merged with other datasets to include more explanatory variables for each institution observation over the same length of time. Specifically, this study relied on the available data from the Classifications for Institutions of Higher Education, a Carnegie Foundation Technical Report, which was produced in 1973, 1976, 1987, 1994, 2000, 2005, and 2010. Because the first three published Carnegie Classification reports—1973, 1976, and 1987—have not been digitized, the use of this data required the authors to hand-code the classification for each observation utilized in the analytical sample.

From the merged dataset, consisting of the full population of higher-education-affiliated institutions that had been granted a patent between 1969 and 2012, an analytical sample had to be drawn from this population to focus on the main university participants in the patent market: research universities; doctoral-granting universities; medical, health, and engineering specialized institutions; and to a lesser extent, comprehensive universities; liberal arts colleges; and other specialized institutions, including schools of art, music, and design, as well as graduate centers, maritime academies, and military institutes. Due to the paucity of observations in the following

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60 Id.


62 The “basic” Carnegie Classifications split Doctoral Granting institutions into four subgroups: Research Universities I and II, and Doctoral-Granting Universities I and II. Research universities originally were considered the leading universities in terms of federal financial support of academic research, provided they awarded a
subgroups, 31 observations from two-year colleges, corporate entities, and spinoff research institutes were dropped from analysis, preserving 591 university observations. Additionally, given that the University of California system does not differentiate patent activity by institution, choosing instead to have reported patent activity in the aggregate in the PTO dataset, it was removed from the analytical sample.

Because the Carnegie Classifications attribute most administrative units to the parent institution, this study took the same approach, collapsing administrative units, foundations, other organizational entities, and former institutions on the current parent institution. However, each observation that received a separate classification from its parent institution in the Carnegie Classifications was preserved as a separate observation from the parent institution. The process of collapsing on parent institution reduced the total number of institutions observed from 590 to 366 school observations, each with 44 year observations.

C. Limitations

It should be noted that the data are limited by two important factors: (1) a lack of explanatory covariates; and (2) a small sample of higher education institutions relative to the overall population of higher education institutions. In the first instance, because the year observations for each institution comprise a 44-year span, it is impractical to match each

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minimum threshold of Ph.D.’s and/or M.D.’s. Doctoral-granting universities were originally conceived of as smaller operations, in terms of federal funding and doctoral production, but comparable in scope to the research universities. Next, the Comprehensive Universities I and II met minimum enrollment thresholds, offered diverse baccalaureate programs and master’s programs, but lacked substantial doctoral study and federal support for academic research. The Liberal Arts Colleges I and II were selected somewhat subjectively in the first several iterations of the Carnegie Classifications; this is particularly the case for Liberal Arts Colleges II, which did not meet criteria for inclusion in the first liberal arts college category but were not selected for Comprehensive University II, either. The Liberal Arts Colleges I included colleges with the most selective baccalaureate focused liberal arts programs. As for the specialized institutions, which are divided into nine categories, the medical, health and engineering schools tended to be stand-alone institutions or institutions affiliated with a parent higher education institution but maintaining a separate campus. Last, the “other specialized institutions” included in the analytical sample are drawn from schools of art, music, and design, as well as graduate centers, maritime academies, and military institutes.

63 As an illustrative example of collapsing an administrative unit on the parent institution, Washington University School of Medicine was collapsed on Washington University. This also applied to foundations and boards of regents, which were collapsed on the flagship institution, given that the vast majority of observations in this dataset are standalone or flagship institutions; for example, the University of Colorado Board of Regents and the University of Colorado Foundation are collapsed on the University of Colorado, given that no other institution from the University of Colorado system appears in the PTO dataset. Finally, independent institutions within the same university system were treated as different observations: the University of Texas Southwestern Medical Center is distinctly observed from the University of Texas at Austin or even the University of Texas at Dallas, the city in which the University of Texas Southwestern Medical Center is located.
institution-year observation with rich, explanatory covariates over that time. Not even the Integrated Postsecondary Education Data System (IPEDS) collected comprehensive data on universities before 1993. As such, the Carnegie Classifications proxy for more detailed information about each institution during a span of years for which data is virtually impossible to find. Given that the Carnegie Classifications select each school to a category on the basis of its federal funding for academic research, production of doctorates, institutional selectivity, enrollment, and degree programs, the Carnegie Classification for each school makes an ideal proxy for a more complete set of explanatory covariates.

As for the size of the analytical sample relative to the population of institutions of higher education receiving a Carnegie Classification since 1973, this population consisted of 1,387 universities—not counting theological seminaries, bible colleges and two-year colleges—while the analytical sample used in this study comprises 366 universities—26.39 percent of the population. However, because this study analyzes university patent activity relative to patent policy change, the analytical sample size is necessarily limited to only those universities that have been granted a patent. As such, the analytical sample used in this study can be viewed as representing a nearly complete picture of the population of academic institutions that have successfully engaged in patent activity between 1969 and 2012.

D. Descriptive Results

Research universities and doctoral-granting universities dominate patenting activity and receive an overwhelming majority of the share of patents granted to academic institutions.

Table 1: Analytical Sample by Carnegie Classification

<table>
<thead>
<tr>
<th>Carnegie Classification</th>
<th>Frequency</th>
<th>Percent</th>
<th>Avg. Patent Total</th>
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<tbody>
<tr>
<td>Research I &amp; II Universities</td>
<td>100</td>
<td>27.70</td>
<td>870.42</td>
</tr>
<tr>
<td>Doctoral-Granting I &amp; II Universities</td>
<td>77</td>
<td>21.32</td>
<td>193.23</td>
</tr>
<tr>
<td>Comprehensive I &amp; II Universities</td>
<td>118</td>
<td>32.68</td>
<td>26.10</td>
</tr>
<tr>
<td>Liberal Arts I &amp; II Colleges</td>
<td>34</td>
<td>9.41</td>
<td>27.29</td>
</tr>
<tr>
<td>Specialized Institutions: Medical, Health, and Engineering</td>
<td>35</td>
<td>9.69</td>
<td>57.80</td>
</tr>
<tr>
<td>Other Specialized Institutions</td>
<td>2</td>
<td>0.55</td>
<td>2.50</td>
</tr>
<tr>
<td>Observations</td>
<td>361</td>
<td>100.00</td>
<td>178.52</td>
</tr>
</tbody>
</table>
However, just under half of the analytical sample is comprised of research universities and doctoral-granting universities, which the Carnegie Classifications consider separate but component parts of its doctoral-granting institution category. The average patent totals for research universities dominate all other classification of institution and are over four times as large as the average patent total for doctoral-granting universities. While comprehensive universities account for the largest proportionate classification in the sample, the average patent total for comprehensive universities is among the smallest in the analytical sample. In fact, it is followed only by the smallest classification in proportion and average patent total—other specialized institutions. Medical, health and engineering schools, while small in number maintain considerable average patent totals, nearly doubling the patent totals of liberal arts colleges, which account for about the same proportion of institutions analyzed in the analytical sample. Across all categories, universities that entered the patent market before the passage of the Bayh-Dole Act buoy patent totals. As such, given their high level of patent activity, the spline regression model results below will especially highlight early entrants as well as research universities, doctoral-granting universities, and medical, health, and engineering schools.

\textit{E. Research Method and Model}

This study employs a spline regression approach to identify how universities reacted to changes in patent policy at key points in time between 1969 and 2012. This method is very similar to using a difference-in-differences approach to compare the activity differences between two series of years separated by a point, or knot, in time, where the intercept and slope vary before and after the knot.\textsuperscript{64} Spline regression modeling necessitates that the location of the knots be set \textit{a priori} in order to produce estimates of the non-linear relationship between the predictor

\textsuperscript{64} \textit{Stata FAQ: How Can I Run a Piecewise Regression in Stata?}, U N I V. OF CALIF. L O S A N G E L E S I N S T. FOR D I G I T A L R E S E A R C H A N D E D U C. (2016), available at: http://www.ats.ucla.edu/stat/stata/faq/piecewise.htm. Effectively, calculating the slope and intercept shifts by hand using spline regression rescales the variable “year” by centering it on the location of the spline knot. For example, the first spline knot (\(k_1\)) is centered on 1981, with all years before it counting up to zero and all years after—but before the next spline knot—counting up from zero. Including the centered “year” variable in the regression equation also requires adding an indicator variable of the intercept before and after the spline knot. Because the model has an implied constant—the intercepts before and after the spline knot should add up to 1—the overall test of the model will be appropriately calculated by hand. To finish estimating the slope and intercept differences by hand, this regression approach requires the use of the “hascons” option, because of the implied intercept constant. Alternatively, the “mkspline” package in Stata 13 can be used to conduct this estimation. Both approaches were used and yielded substantially similar results. The estimates from using the “mkspline” command are reported below for ease of interpretation.
and response variables. Doing this requires defining an indicator variable, using it as a predictor, but also allowing an interaction between this predictor and the response variable.\(^6^5\) The analytical model employed in this study is as follows:

\[
E(PAT_i \mid yr_t) = \beta_0 + \beta_1 CC_i + \beta_2 EE_i + \beta_3 S_i + \beta_4 yr_t + \beta_5 (k_c \geq yr_t > k_{c-1}) + \beta_6 yr_t (k_c \geq yr_t > k_{c-1}) + \varepsilon_{it}
\]

(1)

Thus, the expectation of the total number of patents granted to school \(i\) (\(PAT_i\)) in year \(t\) (\(yr_t\)) is a function of: (1) a vector of the factors attendant to school \(i\) in year \(t\) as proxied by its Carnegie Classification (\(CC_i\)); (2) a dummy variable for whether or not the school engaged in patent activity before 1980 (\(EE_i\)); (3) a school fixed effect (\(S_i\)); (4) the year indicator variable (\(yr_t\)); (5) a dummy variable for the location of the indicator year between the critical spline knots (\(k_c, k_{c-1}\)); (6) the interaction of the indicator year and the dummy variable for its location between the critical spline knots; and (7) the random error term (\(\varepsilon_{it}\)).

Spline knots were set at 1981 (\(k_1\)), 1996 (\(k_2\)), and 2010 (\(k_3\)) to account for: (1) the passage of the Bayh-Dole Act in 1980, which incentivized universities to engage in patent activity by giving them title to inventions produced from federally-funded research; (2) the expansion of the patent protection duration from seventeen to twenty years in 1995; and (3) the introduction of the America Invents Act, which would pass into law in 2011 and change the right to the grant of a patent from a first-to-invent standard to a first-inventor-to-file standard.\(^6^6\) The final spline knot was not set at 2012 for two reasons. First, because 2012 was the final year of observation in the data set, the spline regression model would not tolerate a post-2012 slope prediction without post-2012 data. Additionally, setting the knot at 2012 would not account for the possibility that universities may have begun reacting to the policy before the effective date of the policy change.

From a theoretical perspective, the decision to specify the analytical model with year-after-the-intervention spline knots is defensible on the grounds that it allows an additional calendar year for universities to react to the policy intervention. However, to test the sensitivity of the model and the decision to set the spline knots one year after the policy intervention, the

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\(^{6^6}\) 35 U.S.C. § 301 (permitting universities to take title in inventions and discoveries produced through federally funded research); 35 U.S.C. § 154 (a) (2) (extending the duration of patent protection from seventeen to twenty years); 35 U.S.C. § 100 (i) (changing the right to the grant of patent from first-to-invent to first-inventor-to-file).
model was specified in multiple formats to include spline knots on the year of the policy intervention, one year before the policy intervention, and two years before the policy intervention. This sensitivity test was undertaken to ensure that the differences in slopes and intercepts throughout year observations were not evidencing a secular exponential curve. Although the year-of-the-intervention slopes and intercepts bore marginal similarities to the results discussed below, which are modeled on year-after-the-intervention spline knots, there were significant differences between the year-after-the-intervention slopes and intercepts reported below and those for year-prior- and two-years-prior-to-the-intervention. Thus, the year-after-the-intervention spline knot specification used in this study is preferable to other specifications, because it rules out the potential threat of secular trends.

F. Empirical Results

To analyze the effect of the patent policy changes on university patent activity, the regression model provided in the section above was used to calculate both the intercept before and after the policy intervention as well as the slope before and after the policy intervention. Given that the model employed a fixed effect by institution, the regression results reported below can be interpreted as providing an estimate of the intercepts and effects (slopes) pre-intervention, as well as the marginal intercept shift and slope change after the intervention for universities in the analytical sample. In the first regression table, Table 2, the results compare early entrants to non-early entrants, demonstrating stark differences between the two groups.

Table 2: Knot Differentials (Intercept and Slope) Regular vs. Early Entrants

<table>
<thead>
<tr>
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<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(I)</td>
<td>Non-early</td>
<td>Non-early</td>
<td>Non-early</td>
<td>Early</td>
<td>Early</td>
<td>Early</td>
</tr>
<tr>
<td>Entrants</td>
<td>(0)</td>
<td>(0)</td>
<td>(0)</td>
<td>(0)</td>
<td>(0)</td>
<td>(0)</td>
</tr>
<tr>
<td></td>
<td>(0.00)</td>
<td>(0.268)</td>
<td>(0.00)</td>
<td>(0.146)</td>
<td>(0.273)</td>
<td>(0.460)</td>
</tr>
<tr>
<td>(I)</td>
<td></td>
<td></td>
<td></td>
<td>2.674***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-1981</td>
<td>-0.338</td>
<td>1.416**</td>
<td>0.192***</td>
<td>1.565***</td>
<td>1.180**</td>
<td>9.523***</td>
</tr>
<tr>
<td></td>
<td>(0.813)</td>
<td>(0.571)</td>
<td>(0.0146)</td>
<td>(0.0311)</td>
<td>(0.581)</td>
<td>(0.979)</td>
</tr>
</tbody>
</table>
Notably, the early entrants engaged in patent activity at a modest but steady rate, adding minimally to yearly patent totals and averaging 2.67 patents granted annually by 1980. In 1981, the intercept at this spline knot jumped by an average of nearly one and a half patents in a single year, with an accelerated slope adding to the average growth by three-quarters of a patent every year thereafter to 1995. By 1996, the intercept spiked again, this time by an additional 4.76 patents granted annually for early entrants, with even further accelerated slope gains to 2009. Finally, in 2010, the estimates lacked statistical significance but indicated an added intercept bump and positive explosion in slope. The non-early entrant estimates, though mostly consistent with the statistical significance of the early entrant estimates for the same periods, pale by comparison.

The direction and statistical significance of the results for all early entrants are fairly consistent with estimates for the effect of policy changes at the 1981, 1996, and 2010 spline knots among early entrants in the research and doctoral granting universities classifications. The results comparing the slope and intercept changes around the spline knots for these institutions are provided in Table 3. Of these schools, research universities achieve the greatest orders of magnitude of increased patent grants at the regression spline knots, while the doctoral granting institutions maintained relatively flat but consistent growth in patent activity around the spline knots.
For example, before the passage of the Bayh-Dole Act in 1980, research universities engaged in steady, relatively flat rates of patent activity, averaging about four patent grants per year. In 1981, the intercept for research universities increased by an average of about two patent grants, significantly adding an average of more than one patent grant per year thereafter. In 1996, the research university intercept jumped over seven units but had a relatively stable slope before and after this time. While the limited data after 2010 do not tolerate statistical significance, research universities and doctoral granting universities may have undergone another upward intercept shift, but more importantly, may have also undertaken a momentous slope shift, relative to all other slope shifts observed by category, in the years since 2010.

Table 3: Knot Differentials for Early Entrant Research & Doctoral Granting Universities

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Research</td>
<td>3.860***</td>
<td>1.977**</td>
<td>13.78***</td>
<td>29.54***</td>
<td>2.832</td>
<td>2.291</td>
</tr>
<tr>
<td>Universities</td>
<td>(1.195)</td>
<td>(0.839)</td>
<td>(0.855)</td>
<td>(0.702)</td>
<td>(3.568)</td>
<td>(1.620)</td>
</tr>
<tr>
<td>Doc. Granting</td>
<td></td>
<td>0.531</td>
<td>0.241***</td>
<td>6.237***</td>
<td>2.115</td>
<td>0.458</td>
</tr>
<tr>
<td>Universities</td>
<td></td>
<td>(0.485)</td>
<td>(0.0186)</td>
<td>(0.347)</td>
<td>(1.439)</td>
<td>(0.653)</td>
</tr>
<tr>
<td>(I) Pre-1981</td>
<td>0.185</td>
<td>0.0725</td>
<td>0.569***</td>
<td>0.822***</td>
<td>0.0302</td>
<td>0.0302</td>
</tr>
<tr>
<td>(E) Pre-1981</td>
<td>(0.169)</td>
<td>(0.0686)</td>
<td>(0.0564)</td>
<td>(0.0122)</td>
<td>(0.113)</td>
<td>(0.0686)</td>
</tr>
<tr>
<td>(I) Post-1981</td>
<td>1.117***</td>
<td>0.241***</td>
<td>0.787***</td>
<td>2.291</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(E) Post-1981</td>
<td>(0.0458)</td>
<td>(0.0186)</td>
<td>(0.113)</td>
<td>(1.620)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(I) Pre-1996</td>
<td>13.78***</td>
<td>7.302***</td>
<td>0.569***</td>
<td>0.822***</td>
<td>2.832</td>
<td>2.291</td>
</tr>
<tr>
<td>(E) Pre-1996</td>
<td>(0.0458)</td>
<td>(1.439)</td>
<td>(0.0564)</td>
<td>(0.0302)</td>
<td>(3.568)</td>
<td>(1.620)</td>
</tr>
<tr>
<td>(I) Post-1996</td>
<td>7.302***</td>
<td>0.241***</td>
<td>0.787***</td>
<td>0.252***</td>
<td>2.115</td>
<td>0.458</td>
</tr>
<tr>
<td>(E) Post-1996</td>
<td>(1.439)</td>
<td>(0.0186)</td>
<td>(0.113)</td>
<td>(0.0459)</td>
<td>(1.439)</td>
<td>(0.653)</td>
</tr>
<tr>
<td>Pre-2010</td>
<td></td>
<td>29.54***</td>
<td>3.822***</td>
<td>6.237***</td>
<td>2.115</td>
<td></td>
</tr>
<tr>
<td>Post-2010</td>
<td></td>
<td>(0.702)</td>
<td>(0.113)</td>
<td>(0.0459)</td>
<td>(1.439)</td>
<td></td>
</tr>
</tbody>
</table>

Observations: 3,256 3,256 3,256 1,584 1,584 1,584
R-squared: 0.255 0.253 0.248 0.170 0.168 0.174

Standard errors in parentheses
Oddly, the statistical significance of the medical, health, and engineering schools’ spline knot estimates is lacking around the 1981 spline knot. Yet, the results clearly indicate a significant intercept bump at the 1996 spline knot, after which the slope drops out of significance but may in fact be negative. For these institutions, as well as the research and doctoral granting institutions, the results at the 2010 spline knot indicate a large change in slope but not at statistically significant levels.

| Table 4: Knot Differentials for Specialized Early Entrants (Med., Health, & Engin.) |
|---------------------------------|-----------------|-----------------|-----------------|
|                                 | Specialized Early Entrants | Specialized Early Entrants | Specialized Early Entrants |
| (I) Pre-1981                   | 0.559 (0.694)       |                               |                               |
| (I) Post-1981                  | 0.667 (0.488)       |                               |                               |
| (E) Pre-1981                   | 0.0389 (0.0982)     |                               |                               |
| (E) Post-1981                  | 0.163*** (0.0266)   |                               |                               |
| (I) Pre-1996                   |                               | 2.130*** (0.492)              |                               |
| (I) Post-1996                  |                               | 2.673*** (0.829)              |                               |
| (E) Pre-1996                   |                               | 0.0904*** (0.0325)            |                               |
| (E) Post-1996                  |                               | -0.00924 (0.0651)             |                               |
| (I) Pre-2010                   |                               |                               | 4.798*** (0.406)              |
| (I) Post-2010                  |                               | -0.00357 (2.064)              |                               |
| (E) Pre-2010                   |                               | 0.133*** (0.0175)             |                               |
| (E) Post-2010                  |                               | 0.654 (0.937)                 |                               |
| Observations                   | 572                          | 572                          | 572                          |
| R-squared                      | 0.128                        | 0.141                        | 0.128                        |

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Notwithstanding, the odd results for the specialized institutions, of which there are far fewer than the other subgroups of interest, the statistically significant slope and intercept differentials, while controlling for explanatory covariates, indicate the strong presence of university patent activity responses to patent regime changes at the years represented by the spline knots. This behavioral pattern suggests a rational, profit-maximizing response—the result of strategic firm decisions regarding patent output and resource allocation decisions—to increase patent activity immediately after the implementation of a policy conferring greater patent rights. However, because so many of these patents are sold to patent assertion entities, the increase in university patent activity has the effect of contributing substantially to the patent thicket.

IV. CONCLUSIONS AND IMPLICATIONS
This study asks whether educational institutions exhibit patent activity consistent with firm behavior. The results of the spline regression models suggest that research universities and doctorate-granting universities exhibit firm behavior by increasing their patent activity in direct response to incentives created by changes in patent law. Most notably, across all university types, the Bayh-Dole Act accelerated patent activity once universities could take title in inventions produced from federally-funded research. As illustrated in the regression models and Figure 1 in the Appendix, this act may have even incentivized research universities to disengage in patent activity prior to and just after the passage of the act, in anticipation of the benefit that would be conferred upon them once the act had passed into law. As the patent protection duration expanded in the mid-1990s, the growth of patent activity at most universities in the analytical sample increased markedly, indicating another response to the patent law regime changes. Finally, while not statistically significant because the observation years are too few and the response too varied, preliminary results and the figures in the Appendix indicate that the anticipation of the America Invents Act may have had the largest impact in the rate of patent activity to date, evidence of a university patent activity response to protect current research against a more liberalized granting process. These responses, evincing a move toward patent aggregation by universities, may have lasting impact not only on the patent marketplace but also on innovation.
Patent aggregation, in and of itself, is not problematic, but the symptoms of patent aggregation, such as patent hold-up and rent-seeking licensing behaviors, are detrimental to the promotion of innovation. Thus, it is clear that changes to patent policy—changes that would provide incentives for universities to reap the benefits of research and development of patentable technologies while promoting innovation—are necessary. However, these changes should be clearly administrable, bolster the government’s comparative ability to prefer innovation that is likely to lead to innovative success, and recognize broader rights for researchers and individual innovators who create the patentable inventions.\(^\text{67}\) For instance, if patent grants also included a minimum ownership share for the individual inventor as well as a duty to partner with industry, in order to commercialize the patented innovation, universities could still reap the benefit of their investment while being disincentivized from engaging in patent hold-up and rent-seeking licensing behaviors.\(^\text{68}\) Importantly, these changes should be made to fulfill the constitutional requirements of patent—diffusing innovation efficiently to society.

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\(^\text{67}\) Michael W. Carroll, *One Size Does Not Fit All: A Framework for Tailoring Intellectual Property Rights*, 70 OHIO ST. L. J. 1361-1435 (2009) (supporting a uniform intellectual property right within the distinct domains of copyright and patent); Dov Greenbaum, *Academia to Industry Technology Transfer: An Alternative to the Bayh-Dole System for Both Developed and Developing Nations*, 18 FORDHAM INTEL. PROP. MEDIA & ENTERTAINMENT L. J. 313-411 (2009) (advocating an alternative system to the Bayh-Dole Act and its inefficient local technology transfer offices, and suggesting a centralized and independent office that would have the “infrastructure, informatics and incentives necessary to take advantage of economies of scale in the patenting, licensing and marketing of academic research”).

APPENDIX

Figure 1: Patent Activity for Research Universities

Figure 2: Patent Activity for Doctoral Granting Universities
Figure 3: Patent Activity for Specialized Institutions (Medical, Health & Engineering)