NEW YORK UNIVERSITY
JOURNAL OF INTELLECTUAL PROPERTY AND ENTERTAINMENT LAW

VOLUME 12 | FALL 2022 | NUMBER 1

UNPACKING COASIAN 'RED BOXES': UNIVERSITIES AND COMMERCIALIZATION

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In The Nature of the Firm*, Ronald Coase explains how firms represent a suspension of the market mechanism. The allocation of activities depends on the relative costs of organizing activities within the firm versus direct reliance on the market. Despite Coase's insight, economists often treat firms as black boxes with respect to innovation. Firms take in resources and produce innovations but why firms are successful at innovation is unspecified. As a result, the factors that enable wealth creation within the black boxes of firms, a key factor in economic progress, are little understood. Firms are not the only source of innovation, however. Economically valuable research also emerges from non-profit universities. They represent an alternative (which we term the "red box") to research that occurs within firms' black boxes, an alternative with specific advantages and disadvantages in producing innovations. Using a comprehensive set of patent data, we show that university patenting is largely the result of activity by a tiny subset of U.S. universities, contrary to the Bayh-Dole Act's promise that it would produce a massive technology transfer from universities to the marketplace.*

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In this Article, we argue that research in non-profit universities is distinct from research in a for-profit firm. As a result, the process of moving inventions from the university to the market usually occurs through licensing innovations to firms that have a comparative advantage in assessing possible market value of inventions and can risk capital to exploit innovations. Because successful commercialization of the product of research requires entrepreneurship, we use the insights into entrepreneurship of economists Joseph Schumpeter and Israel Kirzner to begin to unpack the red box of university commercialization efforts. This Article examines the practices that have emerged after the Bayh-Dole Act's grant of intellectual property rights to universities for the results of federally funded research and the many constraints imposed by university structure. It also considers how the differences in the incentive structure with black and red boxes create a role of university research.

Introduction

Research universities funded by governments, non-profits, for-profits, and internal resources generate ideas.[1] Some ideas are purely intellectual

[1] Tens of billions of dollars are spent annually. R1 universities do most of the work but Carnegie Classification also lists schools with less research. *See* Carnegie Classification of Institutions of Higher Education, https://carnegieclassifications.iu.edu/ (last visited Nov. 2, 2022). Some schools, such as Harvard and Texas A&M, spend more than $1 billion a year on research. *See R&D Expenditures of Harvard University from 2006 to 2020*, Statista, (Dec. 2021), https://www.statista.com/statistics/697606/

exercises: interpretations of Shakespeare, understandings of archeological findings, explanations of data on distant stars, or analyses of long-dead philosophers. But considerable resources go to research that has the potential for commercial payoffs: new drugs and medical devices, new seed varieties, improved industrial processes, and new materials. At one time, successful products were largely serendipitous. But since the Bayh-Dole Act gave universities the intellectual property rights to the fruits of federally funded research in 1980, the effort to commercialize research has become both more formalized and more important. Sponsors often want research with potential for commercialization through license agreements or start-ups: "Technology that remains in the lab provides almost no economic benefits."[2] Broader goals include revenue for universities, economic impact for states and communities, and prestige.[3] To get technology out of labs and into the economy, the federal government granted universities intellectual property rights to the federally-funded research conducted by researchers via the Bayh-Dole Act of 1980.[4] This model is spreading internationally as well.[5]

Federal research money has poured into universities since 1980. At the time Bayh-Dole was enacted, the funds up for competition via the National Science Foundation (NSF) and the National Institutes for Health (NIH) were paltry compared to what is at stake now. In fiscal 1980, the NSF was allocated $904

rnd-expenditure-harvard-university/ (last visited Nov. 2, 2022) and Tex. A&M Univ. Rsch. Commc'ns. and Pub. Rels., *First in Texas: A&M Research tops $1 Billion Mark*, Tex. A&M Today (Feb. 10, 2021), https://today.tamu.edu/2021/02/10/first-in-texas-am-research-tops-1-billion-mark/.

[2] Donald E. Stokes, Pasteur's Quadrant: Basic Science and Technological Innovation 85 (1997); *See also* Nathan Rosenberg, *Critical Issues in Science Policy Research*, 18 Sci. & Pub. Pol'y 335 (1991).

[3] Industry trade associations, such as the Association of American Universities publish guides for schools about how to trump the benefits that allegedly come from research, including new businesses. *See* Am. Ass'n of Univs. Econ. Impact Rep., https://www.aau.edu/economic-impact.

[4] Bayh-Dole Act, 35 U.S.C. §§ 200.

[5] Ashley J. Stevens, *The Enactment of Bayh-Dole*, 29 J. Tech. Transfer 93, 93 (2004) ("foreign countries are now adopting the Bayh–Dole model"); Michael S. Mireles, *The Bayh-Dole Act and Incentives for the Commercialization of Government-Funded Invention in Developing Countries*, 76 UMKC L. Rev. 525, 525 (2007); Maria Brouwer, *Entrepreneurship and University Licensing*, 30 J. Tech. Transfer 263, 263 (2005) (European Council points to "U.S. university-business relationships" as "a policy worth imitating"); David C. Mowery & Bhaven N. Sampat, *The Bayh-Dole Act of 1980 and University-Industry Technology Transfer: A Model for Other OECD Governments?*, 30 J. Tech. Transfer 115, 123-124 (2005).

million. In 2021, the allocation was $6,910 billion.[6] Nine schools received more than $100 million in grant money.[7] Adjusting for inflation, this is more than a doubling in real terms of the funds available. The total NIH budget in 1980 was only $3.4 billion.[8] In 2021, its budget was $42.7 billion, more than a fourfold increase in real terms.[9] While not all these funds went to universities, they received the lion's share. The top NIH recipient in 2021, Johns Hopkins University, alone received 1,223 awards totaling $610 million. More than 50 schools received more than $100 million each.[10] Researchers and administrators in non-profit universities aggressively seek more research funding.[11]

Unfortunately, Bayh-Dole was based on an overly simplistic linear model of innovation in which money poured in at the start of an invention pipeline in funding to produce useful commercial innovations at the other end. In some respects, the statute's reliance on a simplistic model is unsurprising – the notion is old.[12] Turning research results into products is not as simple as the linear model makes it out to be; Bayh-Dole took little notice of universities' capabilities. As a result, despite

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[6] Off. of Budget Fin. and Award Mgmt., Nat'l Sci. Found., NSF Requests and Appropriations by Account: FY 1951-FY 2022, https://dellweb.bfa.nsf.gov/NSFRqstApropHist/NSFRequestsandAppropriationsHistory.pdf (last visited Nov. 2, 2022.).

[7] Off. of Budget Fin. and Award Mgmt., Nat'l Sci. Found., Award Summary: Top 50 Institutions FY 2021, https://dellweb.bfa.nsf.gov/top50inst2/default.asp (last visited Nov. 2, 2022).

[8] Off. Nat'l Inst. of Health, History of Congressional Appropriations, 1980-1989, https://officeofbudget.od.nih.gov/pdfs/FY08/FY08%20COMPLETED/appic3806%20-%20transposed%20%2080%20-%2089.pdf (last visited Nov. 2, 2022).

[9] *See* Off. Nat'l Inst. of Health, Mechanism Detail, Actual Obligations, FY 2020-2021, https://officeofbudget.od.nih.gov/pdfs/FY22/spending-hist/Mechanism%20Detail%20for%20Total%20NIH%20FY%202000%20-%20FY%202021%20(V2).pdf.

[10] Medical schools dominate the funding. *See* NIH Awards by Location and Organization Report, https://report.nih.gov/award/index.cfm?ot&fy=2010&static&fm&orgid&view=stateorg&sumcol=fun&sumdir=desc (last visited Nov. 1, 2022).

[11] *See, e.g.*, Am. Acad. of Arts. & Scis., The Perils of Complacency: America at a Tipping Point in Science & Engineering 38 (2020). ("Now is a time of unprecedented opportunity for scientific discovery and rapid progress in technology and its applications."). "Investments in research and education . . . can appear unattractive in the competition for funds under the two-year political cycle of government, the one-year federal budgeting process, and the next-quarter fixation of many of today's businesses." *Id*. at 49-50.

[12] Terence Kealey, The Economic Laws of Scientific Research 8 (1996). Note that Kealey points out that university research was largely, and generously, funded before World War II by private interests. *Id*. at 263-265.

pouring enormous amounts of funding into the innovation pipeline, we still struggle to get relevant research out of the laboratory and into the economy.[13]

Bayh-Dole's results have been mixed. In 1980, at the end of the era when patents based on federally funded research were the property of the agency funding the research, universities were awarded 390 patents. Thirty years after universities acquired the patent rights to the results of federally-funded research, they were awarded more than 3,000 patents.[14] By 2018, a survey found that universities had filed over 17,000 patent applications and received over 7,000 patents in that year alone and held a total of 77,880 patents.[15] But patents have often translated into products. A 2010 study by the Association of University Technology Managers (AUTM) identified 657 products that resulted from university research and development, over 5,000 licenses for technologies, and 650 new companies.[16] Even if it did not produce a flood of products, Bayh-Dole led to more research about commercialization: a survey found 173 articles published on the topic of commercializing university-based research between 1981 and 2005, three-quarters of them appearing between 2000 and 2005.[17] This growth is the source of many of the claims that universities serve as engines of economic development. Unfortunately, only a handful of universities excel at commercialization, including Columbia, Stanford, and the Massachusetts Institute of Technology.[18] "Many

[13] Focusing universities on commercializing research is not universally popular even on economic grounds. Henry Etzkowitz, *Research groups as 'quasi-firms': The invention of the entrepreneurial university,* 32 RSCH. POL'Y 109, 116 (2003) [hereinafter Etzkowitz, *Quasi-Firms*].

[14] *Best Practices in Transforming Research Into Innovation: Creative Approaches to the Bayh-Dole Act: Hearing Before the Subcomm. on Tech. and Innovation Comm. on Sci., Space & Tech.*, 112th Cong. 7 (2012) (statement of Rep. Judy Biggert, Vice Chairwoman, H. Subcomm. on Tech. & Innovation Comm. on Sci., Space & Tech.) [hereinafter H.R. Tech & Innovation Hearing]. That is about a seven-fold increase. Patent activity has been rising generally. During that time period the number of patent issues quadrupled annually. *See* U.S. PAT AND TRADEMARK OFF., U.S. PATENT STATISTICS CHART, https://www.uspto.gov/web/offices/ac/ido/oeip/taf/us_stat.htm.

[15] David Hsu et al., *Benchmarking U.S. university patent value and commercialization efforts: A new approach*, 50 RSCH. POL'Y 104076, *1-2 (2021).

[16] H.R. Tech & Innovation Hearing, *supra* note 14, at 5.

[17] Frank T. Rothaermel et al., *University Entrepreneurship: A Taxonomy of the Literature*, 16 IND. & CORP. CHANGE 691, 695 (2007).

[18] Maria Theresa Larsen, *The implications of academic enterprise for public science: An overview of the empirical evidence,* 40 RSCH. POL'Y 6, 7 (2011). A 2012 Congressional Research Service report found that the vast majority of university-innovation start-up companies over the prior 30 years came from just seven schools. *See* Wendy H. Schacht, *The Bayh-Dole Act: Selected Issues in Patent Policy and the Commercialization of Technology* 10 (2012) (Congressional Research Service). The seven were: MIT, the

universities (in fact, most) do not have the economic capability, manpower, access to venture capital, nor desire to tend to an invention all the way from discovery to commercialization."[19] We argue that the neglect of entrepreneurship by universities is one reason for this lack of success. Despite frequent claims to be entrepreneurial in exploiting research, the survey of 173 articles noted above found few references to actual entrepreneurship among universities.[20]

Success in patenting (a commonly used measure of university research success) varies considerably and just a small number of universities do the vast majority of it. To measure universities' patent performance, we used the PatentVector™ database. PatentVector™ contains the universe of digitized patent documents (both patents and patent applications) for the entire world.[21] An eigenvector centrality algorithm (the same family as Google's PageRank™ algorithm) provides a score for each patent.[22] The score correlates well with

University of California, Cal. Tech., the University of Minnesota, Johns Hopkins University, the University of Utah, and the University of Virginia.

[19] Brian K. Krumm, *University Technology Transfer – Profit Centers or Black Holes: Moving Toward a More Productive University Innovation Ecosystem Policy,* 14 Nw. J. Tech. & Intell. Prop. 171, 189 (2016); *see also* Andy Lockett & Mike Wright, *Resources, capabilities, risk capital and the creation of university spin-out companies,* 34 Rsch. Pol'y 1043, 1044 (2005).

[20] Exceptions are Henry Etzkowitz et al., *The future of the university and the university of the future: evolution of ivory tower to entrepreneurial paradigm,* 29 Rsch. Pol'y 313, 325-326 (2000), which briefly discusses Schumpeter's conception of the entrepreneur, and Nicos Nicolaou & Sue Birley, *Social Networks in Organizational Emergence: The University Spinout Phenomenon,* 49 Mgt. Sci. 1702 (2003), which discusses Kirzner briefly. The most frequent reference is similar in type to this one: "Since the seminal work of Schumpeter (1934), innovation is considered an important driver of economic growth and welfare," with no further mention of Schumpeter or his works. Bart Leten et al., *Science or graduates? How do firms benefit from the proximity of universities?* 43 Rsch. Pol'y 1398, 1398 (2014). I point to this example not to be critical of the article or to single out these particular authors (who have done excellent work on commercialization and universities) but to illustrate the lack of engagement within the literature with economists writing about what is, after all, a particular form of entrepreneurial behavior. This is even more surprising as the literature on entrepreneurship makes use of work by Schumpeter and Kirzner.

[21] An earlier version of PatentVector™ is described in Andrew W. Torrance & Jevon D. West, *All Patents Great and Small: A Big Data Network Approach to Valuation,* 20 Va. J. L. & Tech. 466 (2017). Although the database has grown in many ways since then, the basic structure remains similar.

[22] Eigenvector centrality "awards a number of points *proportional to the centrality scores of the neighbors*." Mark Newman, Networks 159 (2nd ed., 2018). As a result, "a node can achieve high centrality either by having a lot of neighbors with modest centrality, or by having a few neighbors with high centrality (or both)." *Id.* at 160. On PageRank's relationship to eigenvector centrality, *see* Dhruv Parthasarathy, *PageRank – How Eigenvectors Power the Algorithm Behind Google Search,* Dhruv on Math (20 Mar. 2019) available at https://www.dhruvonmath.com/2019/03/20/pagerank/.

extrinsic measures of value and is scaled to make the average patent have a score of 1.0. That is, a patent with a score of 2.0 is twice as central as a patent with a score of 1.0. We included both current and expired patents as we were interested in universities' total performance across time, not just their current portfolios.

There are roughly 4,000 U.S. colleges and universities. Patenting and research activities are far from equally distributed among them. In our calculations, we include only members of the American Association of Universities (AAU), an organization of research universities with relatively stringent membership criteria, and land grant universities, which have a mission to develop and transfer technology to the public, in our data, to avoid having large numbers of observations with zero patents.[23] (There is overlap among the two categories: fourteen AAU members are also land-grant universities, while forty-one are not). We dropped ten universities on the initial list that had zero patents[24] as well as ten that had ten or fewer patents.[25] This left us with ninety-six universities, less than two percent of all four-year U.S. higher education establishments. We searched a comprehensive database, PatentVector™, for each university's patent documents.[26] Table 1 provides summary statistics for our three measures; Table 2 shows the distribution of schools among the AAU and land grant categories. We also considered the public/private status of the universities (32% are private).

[23] We also deleted Canadian universities (some of which belong to the AAU) and land grant-schools affiliated with U.S. territories and Native American tribes.

[24] Central State University, Haskell Indian Nations University, Langston University, Navajo Technical University, Sinte Gleska University, South Carolina State University, University of Guam, University of the District of Columbia, University of the Virgin Islands, and West Virginia State University.

[25] Fort Valley State University, Southern University and A&M College, University at Buffalo, University of Maryland at College Park, Virginia State University, Kentucky State University, Virginia Tech University, Alcorn State University, Alabama A&M University, and Delaware State University.

[26] Because there are occasional typographical errors in patent documents as well as variants in spellings (universities with an "&" in their names sometimes have a patent listed using "and" instead), we used the spelling with the largest number of documents. This captured virtually all of the relevant patent documents for each school. Further, some universities that are part of systems of universities (various University of California universities, schools that are part of the University of Texas and Texas A&M Systems) hold their intellectual property at the system level, our measure over-counts the portfolios of those systems because there is no way to disaggregate the system level data to the campus level.

TABLE 1:
DESCRIPTIVE STATISTICS

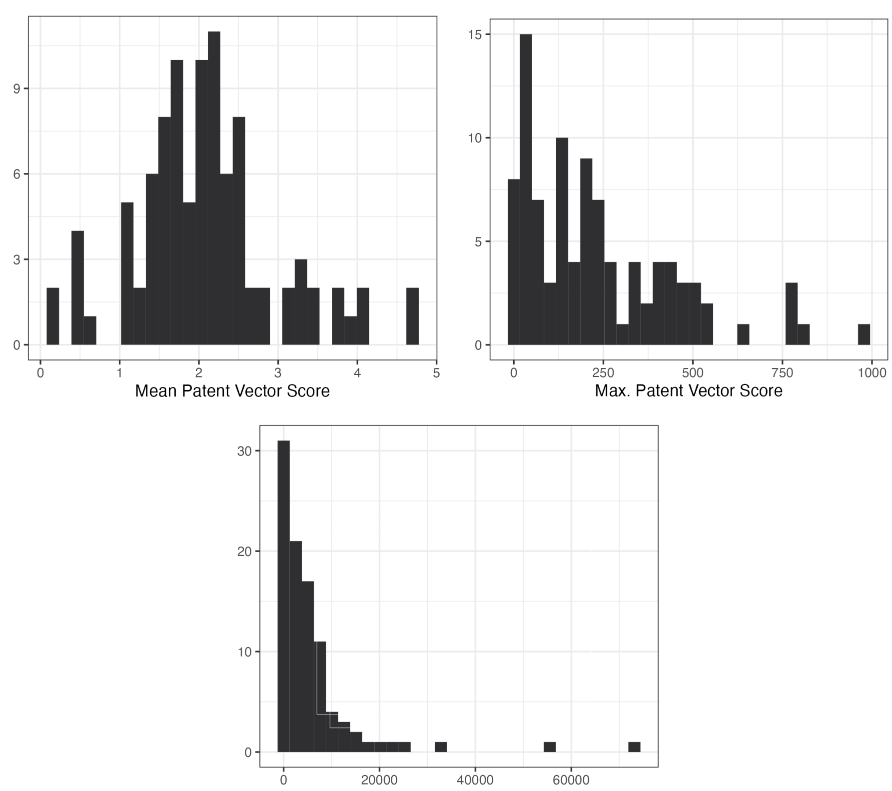
Mean PV Score™	2.08 (0.90)
Max PV Score™	233.47 (212.40)
Patent Documents	6182.58 (10,410)

TABLE 2:
LAND GRANT AAU MEMBERSHIP

AAU \ Land Grant	**Not Land Grant University**	**Land Grant University**
Not AAU Member	0%	0.43%
AAU Member	0.43%	0.15%

Universities perform differently by all three of these measures in Figure 1, which provides histograms for the complete set.

FIGURE 1:
SUMMARY OF UNIVERSITY RESEARCH ACTIVITIES



We see this pattern in Figures 2, 3, and 4 as well, which provide "violin" plots of the data, disaggregated by public, AAU, and land grant statuses. Two conclusions can be drawn from these diagrams and statistics. First, there are substantial differences in the amount of patenting and, more importantly, the amount of patenting of valuable ideas, among universities. Indeed, for measuring the importance of ideas, PatentVector™'s eigenvector-based score is an excellent measure, even better than dollar values, since it represents the centrality of a patent within the network of patented ideas.[27] Just a few universities produce the vast majority of patent documents in our sample: eleven produce half, and twenty-two produce two-thirds.[28] The bottom fifty produce just ten percent of the patent documents.

Examining the patent documents by mean PVScore™ shows that even some small players are successful. Princeton, which is only 35th in total patent documents, tops the list for mean scores at 4.75, followed closely by New Mexico State University, which has only 101 patent documents but an impressive mean of 4.65. Indeed, just MIT and Stanford are in both the top 11 by mean PVScore™ and by number of patent documents. These differences are unsurprising. Even if the University of California System has more high value patents in absolute terms in its more than 73,000 patent documents, it will also have many average or low value ones as well than there will be among Princeton's just over 5,000 or New Mexico State's 101. In calculating the average PVScore™, the thousands of average value ones will dominate the average. In general, the larger bulge higher up for AAU members suggests that those universities are more successful at generating valuable patents. (In future work, we plan to delve more deeply into these statistics and generate additional measures of success.)

[27] NEWMAN, *supra* note 22, at 159. Thus, a patent has a higher score if it is cited by patents which themselves are high scoring. *See also* ZEEV MAOZ, NETWORKS OF NATIONS: THE EVOLUTION, STRUCTURE, AND IMPACT OF INTERNATIONAL NETWORKS, 1816-2001 55 (Cambridge, 2011) ("eigenvector centrality weighs the degree centrality of a given node by the degree centrality of the nodes it is connected with.").

[28] The University of California System, Harvard, MIT, the University of Texas System, Stanford, Johns Hopkins, the University of Pennsylvania, the University of Michigan, the California Institute of Technology, the University of Florida, and Columbia are the top 11; the second 11 are Cornell, Northwestern, Duke, the University of Illinois, the University of Wisconsin, the University of Minnesota, the University of Southern California, the University of Washington, the University of North Carolina, Yale University, and the University of Utah.

FIGURE 2:
MEAN PATENT VECTOR SCORE

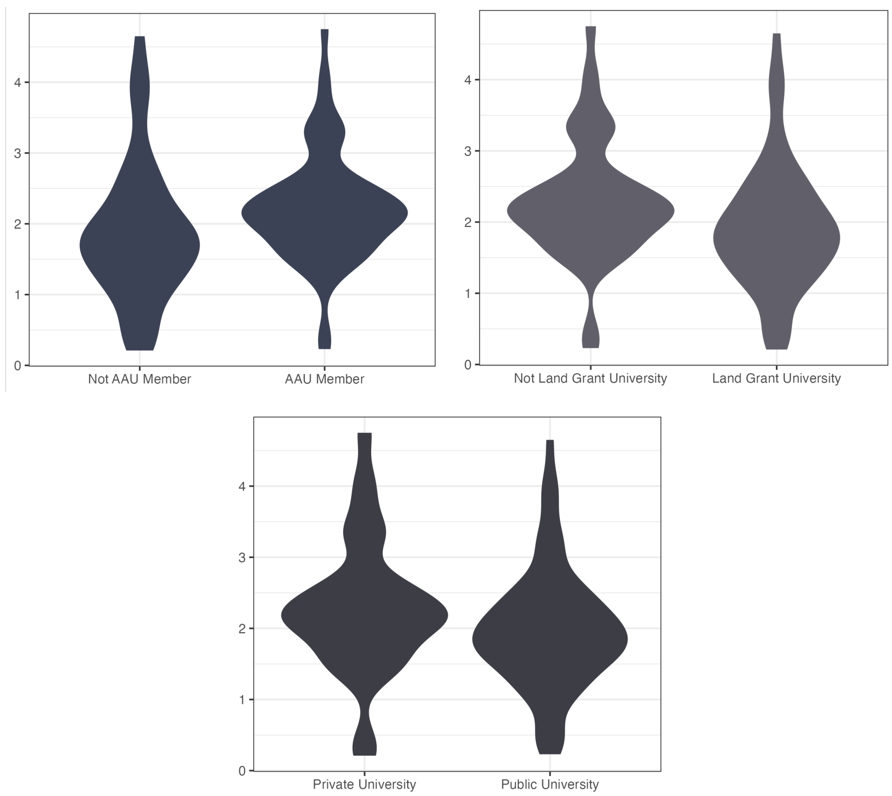
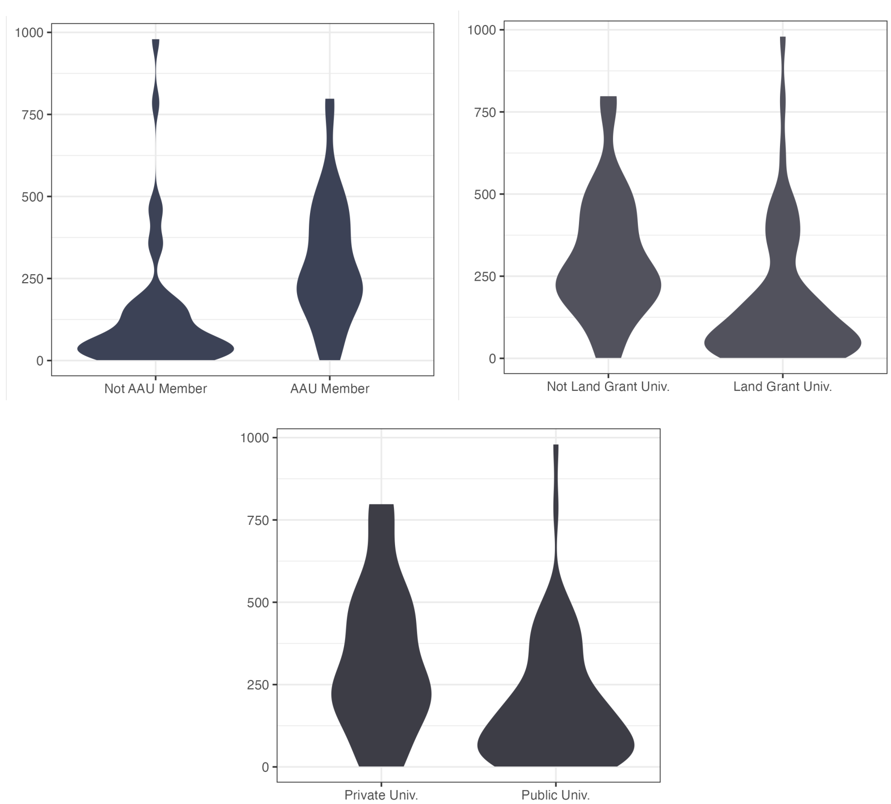


FIGURE 3:
MAXIMUM PATENT VECTOR SCORE



Why haven't the billions of dollars in federal research money led to a broad-based, technology-driven economic boom based on university research? Our argument is that an important reason is that Bayh-Dole, federal policy on innovation, generally, and many university efforts are not built around a realistic model of how innovations become commercial products. In particular, the role of entrepreneurship is neglected by both policymakers and universities. This is unsurprising as, even in the private sector, how firms successfully stimulate innovation is unclear. For the most part, firms are treated in this regard as black boxes, the mechanics of which are skipped over in economic analysis.[29] Even less understood than the private sector is how university research can evolve into market-valued products.

To fill this gap, we turn to the ideas of the economists who studied entrepreneurship, most notably Joseph Schumpeter and Israel Kirzner. Oddly, they are generally ignored in the literature on commercialization of innovations.[30] This

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[29] Professor Nathan Rosenberg of Stanford wrote about this some years ago. *See* NATHAN ROSENBERG, EXPLORING THE BLACK BOX: TECHNOLOGY, ECONOMICS, AND HISTORY (1994). He wanted to "to break open and to examine the contents of the black box into which technological change has been consigned by economists." *Id*. at ix. In the following years, there has not been a rich literature in that regard. There is a literature on incentive structures for CEOs, proper option structures for management, and other financial matters. These analyses – as useful as they are – generally ignore the entrepreneurial function and say nothing about *how* to successfully spur innovation in for-profit enterprises.

[30] Schumpeter was a professor of economics at Harvard in the 1930s and 1940s. He was one of the premier economists of his day, but the Great Depression drew much of the attention of economists to that catastrophe. Works such as John Maynard Keynes' GENERAL THEORY OF EMPLOYMENT, INTEREST AND MONEY, published in 1936, dominated the attention of the profession as Schumpeter's work faded into near obscurity. Thomas K. McGraw, in PROPHET OF INNOVATION: JOSEPH SCHUMPETER AND CREATIVE DESTRUCTION 355 (2007), explains that Schumpeter stated in *Capitalism, Socialism and Democracy* that economics failed "to acknowledge that continuous innovation is 'endogenous to' (inherent in) capitalism." Innovation is not well understood, so is set to the side. Another reason to treat firms as black boxes that are set aside in analysis is that perfect competition lends itself so easily to modeling that it is irresistible to the economics profession but comes at the cost of excluding consideration of creative destruction. *Id*. at 70. Kirzner is one of the leading Austrian economists of recent decades. Following Friedrich Hayek, Ludwig von Mises, and others, he has written, among other things, about invention. Non-Austrian economists, most of the profession, are some variants of neoclassical economics. They study market processes, but generally not the workings of the rather mysterious black boxes of firms, and certainly not the red boxes of universities. In neoclassical models, economic agents maximize choice under constraints. That process simply happens. As Kirzner put it, "Choice, for the economist, has come to mean the solution of a maximization problem." ISRAEL KIRZNER, *Entrepreneurship, Choice, and Freedom* (1979), reprinted *in* THE COLLECTED WORKS OF ISRAEL M. KIRZNER: REFLECTION ON ETHICS, FREEDOM, WELFARE ECONOMICS, POLICY, AND THE LEGACY OF AUSTRIAN ECONOMICS 3 (Peter Boettke & Frédéric Sautet, eds., 2018). On the other hand, Austrian

Article is a step to bring their ideas more fully into the discussion of the conditions relevant to greater levels of valuable innovations that help spur economic progress. We focus on Schumpeter and Kirzner as applied to inventions that occur in what we term the "red box" of universities, which, because they are non-profit institutions, differ significantly from the "black boxes" of for-profit firms.[31] In both instances, the institutional incentive structures are absent from the discussion of the generation of valuable innovations and their evolution into products that succeed in the market.

Developing new ideas and turning them into products and services is the core of the entrepreneurial function: Schumpeter identified the essential function of the entrepreneur as the "doing of new things or the doing of things that are already

economists delve into the functioning and design of institutions as they attempt to understand how things work, unpacking the black boxes of firms in neoclassical theory and rendering the internal incentive structures intelligible. Kirzner explained that the role of social science is to study "the unintended consequence of individual human decisions." ISRAEL KIRZNER, *On the Method of Austrian Economics* (1976), *reprinted in* THE COLLECTED WORKS OF ISRAEL M. KIRZNER: AUSTRIAN SUBJECTIVISM AND THE EMERGENCE OF ENTREPRENEURSHIP THEORY 1-2 (Peter Boettke and Frédéric Sautet, eds., 2015). Unlike standard neoclassical economics, which presumes and studies profit maximization as the core of the functioning of the market economy, in Austrian economics, "[t]he essential element in action is goal pursuit, not maximization, not allocative efficiency, or anything else." ISRAEL KIRZNER, *Ludwig von Mises and Friedrich von Hayek: The Modern Extension of Austrian Subjectivism* (1992), *reprinted in* THE COLLECTED WORKS OF ISRAEL M. KIRZNER: AUSTRIAN SUBJECTIVISM AND THE EMERGENCE OF ENTREPRENEURSHIP THEORY 40 (Peter Boettke and Frédéric Sautet, eds., 2015). Starting in about 1920, "microeconomic theory attained a significantly higher standard of sophistication [with] economists scarcely paying any attention at all to analyzing the ways entrepreneurial activity affects the course of events in markets." ISRAEL KIRZNER, *Entrepreneurship, Economics, and Economists* (1985), *reprinted in* THE COLLECTED WORKS OF ISRAEL M. KIRZNER: AUSTRIAN SUBJECTIVISM AND THE EMERGENCE OF ENTREPRENEURSHIP THEORY 139 (Peter Boettke and Frédéric Sautet, eds., 2015). The same is true of participants in the red boxes of universities. They cannot be modeled to pursue profit maximization in the strict sense that may be presumed of firms; the notion of "goal pursuit" by inventors working in universities would seem more apt. Individual goals likely include higher pay, recognition within the institution, prestige in the profession, self-satisfaction, and revenue from innovation exploitation via commercialization. From the perspective of the innovator, managers of TTOs can serve to further or hinder these goals.

[31] The notion of the firm as a black box has been the standard in economics for about a century. "The idea is to model the firm as a 'black box' in which a finite number of externally purchased inputs are transformed into a finite number of outputs to be sold in the market." Ake Andersson & Borje Johansson, *Inside and Outside the Black Box: Organization of Interdependencies*, THE ANNALS OF REGIONAL SCIENCE 510 (2018). "Red box" is offered to distinguish developments in universities, which are state agencies and non-profit entities, from for-profit "black box" firms.

being done in a new way (innovation)."[32] Finding ways to accomplish this in the context of the university environment requires considering issues raised by the economic theory of entrepreneurship.

Part I of this Article examines how the red box context affects invention. There we develop the analogy to the black box of for-profit firms and explore the differences in incentive structures. Part II describes how U.S. universities approach commercialization. Part III applies an economic perspective to the commercialization process from the perspective of non-profit universities, looking to Schumpeter's and Kirzner's work for guidance on how to understand the process. Part IV concludes with suggestions on how the process might be improved.

I
Invention & Universities

To understand how universities might do a better job at commercializing emerging ideas, we need to be clear about the distinctive features of the red box of the university research environment compared to the black box of the commercial research environment. Hence, we summarize the general state of economic knowledge about working inside firms. This is contrasted to constraints generally faced inside universities. Then we consider how universities treat inventions.

A. Black & Red Boxes

The internal workings of for-profit firms, key actors in market economies and economic progress, were not traditionally well understood by economists. Nobel laureate Oliver Williamson, who works on the issue, notes that economics should "move beyond the older view of the firm as a production function or black box. We need to open the box and examine the mechanisms inside to get

[32] Joseph A. Schumpeter, *The Creative Response in Economic History, in* Essays on Entrepreneurs, Innovations, Business Cycles, and the Evolution of Capitalism 223 (Richard V. Clemence, ed.) (2008 [1947]) [hereinafter Schumpeter, *Creative Response*]. *See also* Joseph A. Schumpeter, *Economic Theory and Entrepreneurial History, in* Essays on Entrepreneurs, Innovations, Business Cycles, and the Evolution of Capitalism 259 (Richard V. Clemence, ed., 2008) (1949) ("entrepreneurship, as defined, essentially consists in doing things that are not generally done in the ordinary course of business routine" and so comes under "the wider aspect of leadership"); Joseph A. Schumpeter, *Capitalism, in* Essays on Entrepreneurs, Innovations, Business Cycles, and the Evolution of Capitalism 199 (Richard V. Clemence, ed., 2008) (1946) [hereinafter Schumpeter, *Capitalism Essay*] (entrepreneurs are not about financing of new firms but about organizational activity).

a better understanding of what is going on and why."[33] He notes further that "Innovation poses special challenges," some of which are addressed by focusing on transaction costs, but there is no "well-rounded explanation."[34] Williamson's work is complemented by that of Oliver Hart, also a Nobel Prize recipient (with Bengt Holmstrom) for "contributions to contract theory."[35] Hart notes that "In modern microeconomics textbooks, the firm is still represented in purely technological terms as a production function or production set."[36] In short, in standard economic theory it is presumed that diligent managers run organizations on behalf of the owners who wish to maximize profits. These managers face perfect competition in completely developed markets.[37] Such assumptions allow effective modeling of activity outside the firm, but do not help understand what goes on inside the not-well-understood black box. Williamson, Hart, and others have advanced our understanding of how firms solve incentive problems (winning two Nobel Prizes while doing so), but how firms innovate remains relatively under-theorized.

The economics of the firm begin with the recognition that because organizing and operating firms is costly, there needs to be an economic rationale for their existence.[38] Nobel Laureate Ronald Coase explained in his 1937 article, *The Nature of the Firm*, that firms exist where the transaction costs of organizing and operating a firm are less than the transaction costs of operating in the market.[39]

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[33] *An Interview with Oliver Williamson*, 3 J INSTITUTIONAL ECON. 373 (Oct. 2007). Williamson was awarded the Nobel Prize "for his analysis of economic governance, especially the boundaries of the firm." *See Sveriges Riksbank Prize in Economic Science in Memory of Alfred Nobel 2009, Oliver E. Williamson Facts*, THE NOBEL PRIZE, https://www.nobelprize.org/prizes/economic-sciences/2009/williamson/facts/ (last visited Nov. 2, 2022).

[34] *An Interview with Oliver Williamson, supra* note 33, at 376.

[35] *Sveriges Riksbank Prize in Economic Science in Memory of Alfred Nobel 2016, Oliver Hart Facts*, THE NOBEL PRIZE, https://www.nobelprize.org/prizes/economic-sciences/2016/hart/facts/ (last visited Nov. 2, 2022).

[36] That is, the internal process is a mysterious black box. *See* Oliver Hart, *Thinking about the Firm: A Review of Daniel Spulber's The Theory of the Firm*, 49 J. ECON. LIT. 101, 102 (Mar. 2011).

[37] *Id*. Hart notes that economists recognize that this is a near caricature of the real world but is still the most useful model that exists. Other models of firms, from sociology and organizational behavior theorists are "not yet at a stage of theoretical or empirical precision that [they] can be incorporated into mainstream economic thinking."

[38] *An Interview with Oliver Williamson, supra* note 33, at 380 ("[T]he firm is beset with bureaucratic costs that probably deepen over time.").

[39] If markets allocate resources efficiently, such organizations that incur transaction costs in dealing with various parties should not be needed. But they are, precisely because there are transaction costs to operating in the market as well. Ronald H. Coase, *The Nature of the Firm,* 4 ECONOMICA 386 (1937).

While Coase's observation was eventually recognized as brilliant, it failed to spur further development by economists about the internal workings of firms for several decades.[40] As that work developed, it yielded some insights. For example, while firms exist to reduce transaction costs, the savings from their creation can be transitory as "bureaucratic costs build up."[41] In more recent years, a rich literature has arisen on the role of contracts as firms deal with each other.[42]

As a result of this work, we know that firms engage in complex processes that no one person can grasp. Parties are brought to work together to further the objectives of the firm. But why firms are designed internally the way they are, where great variation is observed, is not as well understood.[43] With respect to research and innovation within a firm, managers must grant authority to those with superior technical knowledge.[44] This poses challenges to the firm in constraining resources to focus on areas of greater profit potential, because managers rarely have the same grasp of the scientific issues as the researchers they employ. In the context of non-profits like universities, there are even greater challenges to understanding the impact of their organization on the incentives facing researchers and others.[45]

The puzzle we need to address is thus why universities play such a large role (at least in dollar terms) in research. In other words, does funding research in universities serve an important function, distinct from that of for-profit firms,

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[40] Hart, *supra* note 36, at 105. Work furthering the questions raised by Coase "resumed" in the 1970s as scholars hypothesized about the different forms of organization firms would take, such as more internal command-and-control work versus dealing through contracts with outside firms.

[41] *An Interview with Oliver Williamson*, *supra* note 33, at 380.

[42] Hart, *supra* note 36, at 103. Hart discusses issues such as moral hazard, when managers exploit their employing firms for personal gain, and principal-agent issues, when key parties in the firm have divergent interests that cannot be fully accounted for by contract such as in compensation schemes for top managers. Economists do not presume to have "solved" such problems, but the issues are much studied. For example, Hart focuses on efficiency in negotiated contracts across firms that are used to resolve the conflicts that are inherent as self-interested parties come together. This comes into play in issues such as who owns what assets across organizations. Part of the technical literature that has evolved concerns property rights within organizations and the tensions among the parties involved—who gets ownership and control? While there is agreement in the literature that most economic growth arises from value-increasing activities within firms, exactly why this should be so is not well understood. *Id*. at 107.

[43] *Id*. at 107.

[44] *Id*. at 108. Hart does not use the example of complex research, but research clearly fits the situations in which he discusses downward allocation of authority within a firm.

[45] *Id*. at 111. While Hart notes that there is a literature on nonstandard forms of organizations, such as non-profit entities, this does not yet appear to have produced scholarship relevant to the question raised here.

in developing research that leads to commercial products. Significant public and private money are invested in research at universities; why? Are there reasons to believe red boxes have advantages under certain conditions over black boxes?

Table 3 summarizes some key differences in the internal incentive structures within black and red boxes. First, the two organizations have different objective functions. Firms focus on profit maximization and universities on maximizing revenue and prestige (recognized by things such as quality publications, prizes, and student placements). We should thus expect different behaviors from identical researchers depending on which environment the researcher works. We should also expect sorting between black and red box organizations in the characteristics of researchers who seek employment in each.

Table 3:
Comparison of Black/Red Boxes: Focus on Research

	"Black Box" / Private Firms	**"Red Box" / Universities**
Objective function	Profit maximizing	Revenue and prestige maximizing
Constraints	Market Budget (investor)	Disciplinary acceptance Budget (donor, funder)
Decisionmaker on research direction	Primary: Directors Secondary: Executives	Primary: Researcher Secondary: Grant making organizations
Primary outputs of research	Primary: Products Secondary: Patents	Primary: Papers Secondary: Patents
Enforcement mechanisms for dealing with researchers	File researcher	Revoke tenure or Reduce quality of work conditions
Ownership of research results	Firm with possible special rewards for researcher	University with profit sharing with researcher

Second, the constraints in red and black boxes differ. While both face budget constraints, the constraints are quite different. Firms must attract investors (different kinds at different stages of development, but all motivated by the desire to profit); investors are interested in firms' potential to grow net revenue. Investors often want to see results within a specific time frame.[46] Universities must attract investments from donors and funding agencies, whose motives are not the same as for-profit investors. Universities generally do poorly at attracting investment in university-developed technologies because they do not operate on the same

[46] Bob Zider, *How Venture Capital Works,* Harv. Bus. Rev. (Nov.-Dec. 1998), https://hbr.org/1998/11/how-venture-capital-works ("In essence, the venture capitalist buys a stake in an entrepreneur's idea, nurtures it for a short period of time, and then exits with the help of an investment banker.").

time scale as venture capitalists or other potential profit-minded investors.[47] Firms also are subject to market constraints: they must produce goods people will buy. Universities, on the other hand, seek rewards from scientific (disciplinary) bodies that award prizes and grants, offers of lectureships and publication, etc. for successful faculty.

Third, the decision makers who determine research direction are different. In firms, the primary decision makers are the firm's directors, who decide the overall direction. Secondary (day-to-day) decision makers are executives who allocate resources and approve research projects. In universities, the primary decision-makers are the researchers themselves, who are not assigned to projects but generate their own research agendas and funding. Hence, the research funders play a major role. Few major scientific research endeavors will proceed beyond the pilot stage in a university if they do not receive external funding. (The median NSF grant in FY 2021 to an engineering department was about $127,000).[48] The researcher is the primary decision-maker because the researcher determines whether or not to initiate a project, even if its funding depends on outside sources. The NSF reports that principal investigators submit "about 2.3 proposals for every award they receive."[49]

Fourth, researchers in firms produce ideas that may be patented as part of products offered in the market (possibly yielding revenue streams even if the firm where they are developed does not exploit them). University researchers may also produce research that yields patents, but this is generally less important than the production of scholarly papers. (Some critics of commercialization in universities allege that producing papers and patents are in conflict, although evidence suggests this is false.[50])

[47] *See* WILLIAM HOFFMAN & LEO FURCHT, THE BIOLOGIST'S IMAGINATION: INNOVATION IN THE BIOSCIENCES 181 (2014).

[48] OFF. OF BUDGET FIN. AND AWARD MGMT., NAT'L SCI. FOUND., FUNDING RATE BY STATE AND ORGANIZATION FROM FY 2021 TO 2022 FOR NSF, https://dellweb.bfa.nsf.gov/awdfr3/default.asp (last visited Oct. 31, 2022).

[49] OFF. OF BUDGET FIN. AND AWARD MGMT., NAT'L SCI. FOUND. MERIT REV. FACTS, https://www.nsf.gov/bfa/dias/policy/merit_review/facts.jsp (last visited Oct. 31, 2022).

[50] *See* Bart Clarysse et al., *Academic Spin-Offs, Formal Technology Transfer and Capital Raising*, 16 INDUS. & CORP. CHANGE 609 (2007).

Fifth, when a researcher is unproductive or does not follow guidance, a firm can fire them. Universities, on the other hand, have more trouble getting rid of unproductive researchers, particularly once they are tenured.

Lastly, firms and universities differ in ownership of research results. Firms generally own internal or contracted research results; researchers (especially productive ones) may receive a share of the rewards, but this is a matter for individual negotiations. Since Bayh-Dole, universities generally own the intellectual property rights (or have a right of first refusal to it) for research done on campus, but they usually share net profits with the researchers when results are commercially exploited.

The differences between university and corporate approaches are also illuminated by considering the small number of corporate laboratories widely recognized as successful at producing innovation: Bell Labs, IBM Research, and Xerox's Palo Alto Research Center (PARC)[51]. All three bear a striking resemblance to universities in many of the dimensions described above.

These labs focused on getting smart researchers together and then letting them pursue their own agendas. AT&T created Bell Labs to access what its president termed in a 1958 speech a "special brand of brains."[52] Bell Labs freed them from worrying about AT&T's actual businesses: "Researchers were thus free to select their own research topics without worrying about business relevance or

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[51] These labs were quite unusual. *See* ROBERT BUDERI, ENGINES OF TOMORROW: HOW THE WORLD'S BEST COMPANIES ARE USING THEIR RESEARCH LABS TO WIN THE FUTURE 44 (2000) (noting that "only the biggest and most dominant labs, such as IBM and Bell Labs, ever engaged in this type of basic research – and it was never more than perhaps 1 percent of the total research effort."). Even at these companies, core research and development got far more of the corporate attention than is often realized. William L. Keefauver, *in* BELL LABS MEMOIRS: VOICES OF INNOVATION 267, 279 (A. Michael Noll Michael Geselowitz eds., 2011) ("Bell Labs was best known from its published papers and inventions, most of which came from the research organization. But this was just ten percent of the company. The other organizations performed systems engineering and development."). Michael Hiltzik notes that "No corporate lab exists today that resembles the PARC of the 1970s and 1980s, not even the PARC of the 1990s, where great advances are made in physics, information science, and graphic technologies." He attributes this in part to changes in technology, but also in business: "No company, no matter how wealthy, dares devote even a fraction of its wealth to a search for knowledge that may not produce a return to the bottom line, as Xerox did. The utopian ideal of a corporate laboratory whose scientists are free to roam through Ideaspace draws only ridicule today." MICHAEL A. HILTZIK, DEALERS OF LIGHTNING: XEROX PARC AND THE DAWN OF THE COMPUTER AGE 397 (2000).

[52] NARAIN GEHANI, BELL LABS: LIFE IN THE CROWN JEWEL 44 (2003).

management approval. They could even ignore management suggestions or stop working on a topic without the fear of serious negative repercussions, provided the research led to good results."[53] As one Bell Labs researcher put it, AT&T had determined that "freedom to pursue one's own ideas and stable, long-term funding were the best well-springs of innovation."[54] Likewise, PARC's managers believed "that the only way to get the best research was to hire the best researchers they could find and leave them unburdened by directives, instructions, or deadlines. For the most part, the computer engineers at PARC were exempt from corporate imperatives to improve Xerox's existing products. They had a different charge: to lead the company into new and uncharted territory."[55] Similarly, "[f]rom 1945 up until the 1990s IBM Research was funded primarily by headquarters and by the hardware and software divisions. The scientists had their own research agenda with some occasional technology transfer, but this was not the norm."[56] Looking back on over a decade of work there in 1966, IBM's European research director reflected that the company's Swiss facility had proven to be "a breeding ground for ideas that lie outside the mainstream and that, accordingly, would find it difficult to be accepted in the large central organization,"[57] hardly a description of an organization focused on developing commercial products!

Funding in these labs was unrelated to business purposes. While it was an effective monopoly (before the antitrust suit led to the company's breakup),[58] "AT&T was generous in funding Bell Labs [as were IBM and Xerox in funding their laboratories], but until the late 1980s, they did not seem to care what Bell

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[53] *Id*.

[54] Manfred R. Schroeder, *A Dream Come True*, *in* Bell Labs Memoirs: Voices of Innovation 65, 66 (A. Michael Noll & Michael Geselowitz eds., 2011).

[55] Hiltzik, *supra* note 51, at xxii.

[56] Christopher Sciacca & Christophe Rossel, *The Evolution of IBM Research: Looking Back at 50 Years of Scientific Achievements and Innovations*, 45 Europhysics News 16, 18 (2014), https://www.europhysicsnews.org/articles/epn/pdf/2014/02/epn2014452p16.pdf.

[57] Ambros P. Speiser, *IBM Research Laboratory Zurich: The Early Years*, 20 IEEE Annals History Computing 15, 27 (1998).

[58] Gehani, *supra* note 52, at 46 ("It used to be that AT&T was happy to let researchers reach out for the sky and make Bell Labs famous. AT&T basked in reflected glory, which did not cost it anything in the monopoly days, since it was allowed to pass on the costs to its customers. However, when AT&T shed its monopoly status, the rules of the game changed, which meant that AT&T would have to fund Bell Labs from its revenues, thus reducing its profits.").

Labs did or did not do as long as they excelled at science."[59] A similar change happened around the same time at IBM[60] and at PARC, as Xerox's financial position deteriorated.[61]

Many descriptions of these labs explicitly analogize to university environments. For example, Bell Labs is described as being "like a university that had no students, a zero teaching load, no tenure problems, no running around for grants, and plenty of money for equipment and travel. A researcher could focus on building his or her professional credentials and reputation. Within a few years, with Bell Labs on his or her resume, the researcher would have a passport to a tenured position at one of the top universities or would be able to walk into a senior research position at one of the industrial research labs."[62] One Bell researcher recalled that "we had all the benefits of academic freedom, along with good resources, and none of the teaching or administration loads that our counterparts in academia usually faced. Furthermore, compared to academia at that time, the pay was relatively good."[63] PARC's university-like atmosphere was partly the result of most of its staff being recruited from universities.[64] One of its researchers recalled, "A lot of us even came to feel we were sort of like university instructors who got to spend all our time doing research without having to teach classes."[65]

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[59] Gehani, *supra* note 52, at 42. For example, one Bell Labs researcher described how he worked on "[t]he double-stream amplifier," which he described as "a member of a large class of devices and inventions – wonderfully ingenious, and good for nothing." *See* John R. Pierce, *My Career as an Engineer: An Autobiographical Sketch by John R. Pierce* (1988), *reprinted in* Bell Labs Memoirs: Voices of Innovation 21, 39 (A. Michael Noll & Michael Geselowitz eds., 2011). This was not entirely altruistic: as one researcher noted, before 1984, AT&T wrote off its research budget at Bell Labs as a business expense. Schroeder, *supra* note 50, at 86.

[60] *See* Buderi, *supra* note 51, at 27-28; Bart Ziegler, *IBM's Research Cutbacks Now Seem to be Brilliant*, W.S.J. (Oct. 6, 1997), https://www.wsj.com/articles/SB876088040424995OO (describing IBM research cutbacks in early 1990s).

[61] *See* Hiltzik, *supra* note 51, at 377.

[62] Gehani, *supra* note 52, at 44. Indeed, in many ways it was "better than a university, especially for those interested in pursuing a research career and who did not care about teaching." *Id*. at 53. Gehani analogizes to universities for Bell Labs' emphasis on publications, hiring practices, and "freewheeling university-like research." *Id*. at 71, 110, 141-42.

[63] Alan G. Chynoweth, *At the Shining Laboratory on the Hill, in* Bell Labs Memoirs: Voices of Innovation 139, 157 (A. Michael Noll & Michael Geselowitz eds., 2011). *See also* Hiltzik, *supra* note 51, at 147 ("Once accepted into the [PARC] lab, you were immune to the petty harassments common to university departments.").

[64] *See* Hiltzik, *supra* note 51, at 58.

[65] *Id*. at 59.

Financial constraints were loose at these labs. A Bell researcher nostalgically recalled how he would let a computer run for entire weekends at a cost of $600 per hour, with the only consequence being that his budget was increased.[66] Similarly, Hiltzik concludes in his history of PARC that a key factor in its success was "Xerox's money, a seemingly limitless cascade of cash flowing from its near-monopoly on the office copier."[67]

Once ATT's breakup forced the company to behave more competitively, it began to expect "Bell Labs to help it compete by developing technologies that would lead to new products and services."[68], at 46. When much of Bell Labs was spun off to Lucent, one of the successor businesses, a Lucent executive asked a researcher what he did that was of value to Lucent. The researcher could not answer, finally saying, "This is a new way of looking at long-term research for me."[69] Similarly, when IBM Research changed its motto from "famous for its science and technology and vital to IBM" to "vital to IBM's future success," half the physics research team left in response.[70] Even internal IBM researchers note that the shift to focus on "actual customer problems" was "a completely unheard-of concept at the time."[71] Corporate demands for focus were not the only consequence of the breakup; fear of violating antitrust laws made researchers reluctant to collaborate.[72] And when Xerox imposed a more corporate-minded manager on PARC, one of the changes he made was that 50% of researchers' evaluations would be based on how well they worked with the developing and manufacturing units of the company.[73]

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[66] Schroeder, *supra* note 54, at 86.

[67] Hiltzik, *supra* note 51, at xxi.

[68] Gehani, *supra* note 52

[69] *Id*. at 60-61. The Alcatel-Lucent executive who ran Bell Labs noted that "[p]erhaps the most significant difference is our focus on coupling innovation with the needs of the marketplace." Jeong H. Kim, *Foreword*, *in* Bell Labs Memoirs: Voices of Innovation 1, 5-6 (A. Michael Noll & Michael Geselowitz eds., 2011).

[70] Gehani, *supra* note 52, at 147.

[71] Sciacca & Rossel, *supra* note 56, at 19.

[72] Chynoweth, *supra* note 63, at 174 (after breakup, "fear of breaking the anti-trust conditions caused, in effect, an Iron Curtain to descend between hitherto close colleagues. We were afraid to have any discussions with each other except in the presence of lawyers. Gradually, we learned what we could and could not do but it was a very distasteful and dissatisfying experience, to say the least.").

[73] *See* Hiltzik, *supra* note 51, at 377.

The result of this freedom was considerable innovation.[74] Bell Labs produced key breakthroughs in multiple areas, from lasers to semiconductors. PARC invented technologies still at the core of modern computer interfaces, from computer mice to graphical interfaces. IBM Research developed leading edge technologies in hardware and software, but also including the "Deep Blue" system that eventually bested Gary Kasparov at chess and the scanning tunneling microscope.[75] While their corporate parents sometimes benefited from these innovations, the dominant strain in researchers' recollections of their time at these institutions is that the company sponsors cared little about practical uses of what the researchers did.

It is striking that when companies could afford it and sought to "lead the company into new and uncharted territory"[76] as Hiltzik described PARC's mission or Bell Labs' mission "to advance the nation's telecommunications network,"[77] they sought to replicate conditions much like those in universities. This suggests that there is something about the conditions within the red box that produce innovation which is unavailable in the black box.

The different incentive structures we find when we open the black and red boxes thus points to the importance of the different internal incentive structures and decision processes to at least some types of innovation. We should therefore expect that researchers will behave differently in different boxes and that the boxes should attract different types of researchers.[78] The combination of the differences in behavior and the differences in structure likely make the research output of a red box different from the output of a black box. Buying research from a red box supplier rather than from a black box supplier may thus be an appropriate choice under some circumstances but not under others.

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[74] *See* GEHANI, *supra* note 52, at 45 ("Bell Labs thus offered its scientists an environment where they could think out of the box in the pursuit of innovation and invention. As a result, Bell Labs scientists came up with numerous inventions many of which, such as the transistor, the active communications satellite, and the laser, had a profound effect on society.").

[75] *See The First Corporate Pure Science Research Laboratory*, IBM, https://www.ibm.com/ibm/history/ibm100/us/en/icons/scientificresearch/ (last visited Oct. 26, 2022).

[76] HILTZIK, *supra* note 51, at xxii.

[77] GEHANI *supra* note 52, at 175.

[78] Kealey notes that universities were attracting faculty with the freedom to research at least as early as the 1700s. *See* KEALEY, *supra* note 12, at 77.

B. What Makes University Research Different?

University research differs from research at for-profit firms in important ways. First, academic and research faculty, staff, and students, who have significantly more discretion in their research programs than do most black-box researchers, produce most university-based research.[79] Their discretion may include what they research and whether or not they seek intellectual property protection for the fruits of their research.[80]

Unlike employees in a corporate research laboratory, to gain a commercially viable invention, academic researchers must be persuaded to focus attention on problems of interest to the outside world and to conduct research to make it possible to commercialize or otherwise move it into the marketplace.[81] Many rewards in universities are correlated with dissemination of ideas that are potentially inconsistent with commercialization. A common story among TTOs is one of getting phone calls from a researcher about to board a plane for a conference to give a presentation, the contents of which could disclose a potentially patentable idea. The researcher wants to know: "Can we get a patent before my talk tomorrow?"[82]

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[79] *See* Nicholas S. Argyres & Julia Porter Liebeskind, *Privatizing the Intellectual Commons: Universities and the Commercialization of Biotechnology*, 35 J. ECON. BEHAV. & ORG. 427, 431 (1998); *see also* Trevor Grigg, *Adopting an Entrepreneurial Approach in Universities*, 11 J. ENG'G TECH. MGMT. 273, 282 (1994).

[80] *See* Ajay Agrawal & Rebecca Henderson, *Putting Patents in Context: Exploring Knowledge Transfer from MIT*, 48 MGMT. SCI. 44, 58 (2002) ("Most faculty... suggest they are engaged in a research stream they find interesting and challenging, and that they make patent or publish decisions on a case-by-case basis."); Richard Jensen & Marie Thursby, *Proofs and Prototypes for Sale: The Licensing of University Inventions*, 91 AM. ECON. REV. 240, 243 (2001) (survey found "convincing faculty to disclose inventions is a major challenge."). In a survey of 62 TTOs, Jensen, Thursby, & Thursby reported that:

> Many directors believe that substantially less than half of the inventions with commercial potential are disclosed to their office. Faculty may not want to disclose for a variety of reasons ranging from not being able to realize an invention has commercial value to not wanting to take time away from their research. Many faculty may not want to get involved in licensing because, as reported in the survey, faculty involvement in further development (even after a license is executed) is necessary for commercial success for 71% of inventions licensed.

Richard A. Jensen et al., *Disclosure and Licensing of University Inventions*, 21 INT'L J. IND. ORG. 1271, 1272 (2003).

[81] *See* DEREK BOK, UNIVERSITIES IN THE MARKETPLACE: THE COMMERCIALIZATION OF HIGHER EDUCATION 62 (2003) (if faculty "have to choose between the kind of research they enjoy and earning large sums of money, they rarely prefer the latter.").

[82] Morriss visited over twenty TTOs while working on technology transfer for his university and heard a variation on this story at virtually everyone.

As publications and presentations are primary coins of the realm in academia, that this is a frequent enough experience to enter the broader lore is unsurprising. This also illustrates the difficulty TTOs face in balancing their need to seek intellectual property protections for ideas and faculty members' needs to publish the results of work in a timely way.

Second, researchers in universities are sequestered, at least in part, from market pressures.[83] University administrators worry about budgets, but most research faculty enjoy the freedom to not worry about those pressures[84] and many likely sought positions in the academic world to avoid research dictated by market-driven employers. Indeed, significant freedom from market pressures is an important attribute of faculty culture.[85] They may be able to choose whether to pursue commercialization of a particular research result or to release it into the public domain. A fundamental justification for university-based research is that it provides a public good (basic research) that firms under provide.[86] To demonstrate their economic impact, both methods can provide universities with concrete examples of benefits to persuade federal and state legislatures to provide financial support.

[83] *See* GARY C. FETHKE & ANDREW J. POLICANO, PUBLIC NO MORE: A NEW PATH TO EXCELLENCE FOR AMERICA'S PUBLIC UNIVERSITIES 70 (2012).

[84] That is, university researchers need not worry about general revenue pressures but, individually, they do worry about obtaining funding, such as NSF money, to justify continuing their preferred research programs. There are, of course, exceptions to this. *See, e.g.*, KEALEY, *supra* note 12, at 335-36 (describing authoritarian laboratory a colleague worked in and concluding that, although rules like those he describes are a denial of "the intellectual spirit" they are increasingly common).

[85] U.S. universities have closer ties with industry than many other nations, in part because of their dependence on local and private support. *See* DAVID C. MOWERY ET AL., IVORY TOWER AND INDUSTRIAL INNOVATION: UNIVERSITY-INDUSTRY TECHNOLOGY TRANSFER BEFORE AND AFTER THE BAYH-DOLE ACT 13 (2004). Kealey notes that the pressure to obtain grants may inhibit this: "[G]rant-giving bodies which are accountable to government try only to give money for experiments that are likely to work. But experiments that are likely to work are probably boring – indeed, if they are predictable, they are barely experiments at all; rather, they represent the development of established science rather than the creation of the new. . . ." KEALEY, *supra* note 12, at 87.

[86] Agrawal & Henderson, *supra* note 80, at 45; Argyres & Liebeskind, *supra* note 79, at 431.

Third, university hierarchies are structured differently from firms'.[87] Coase described firms as alternatives to the market organization of transactions;[88] universities are another form of such an organization. Coase quoted economist D. H. Robertson's image of firms as "islands of conscious power in this ocean of unconscious cooperation like lumps of butter coagulating in a pail of buttermilk" to illustrate the differences between firms and the market.[89] In Coase's formulation, firms offer a command-and-control structure in place of a market. Transactions occur within firms when the net advantages of command-and-control are greater than those of the decentralized marketplace and the unconscious coordination of the price mechanism.[90] We posit that universities fall between the solidity of the firms-as-lumps-of-butter and the fluidity of the marketplace-as-buttermilk. Universities' collective governance means that they have 'less conscious power' than most firms but they are nonetheless more 'solid' than the marketplace and they lack the coordinating mechanism of an internal price mechanism.[91] Organizing research within a university in pursuit of some goal is likely less clear than in a 'more solid' for-profit company. The looser constraints universities provide is a

[87] Grigg additionally describes universities as "complex organizations" and having "vague and ambiguous goals", which fits within this categorization. Grigg, *supra* note 79, at 279.

[88] Coase, *supra* note 39, at 389 ("[T]he distinguishing mark of the firm is the supersession of the price mechanism."). That is, the pure competition economic model is based on trades of generic commodities where individual actors matter little. There are many buyers and sellers of the same thing; each making individual decisions but no actors, individually, can dictate outcomes. In firms, as in universities, decisions are hierarchical and dictate at least portions of the outcomes—resources within organizations are distributed by command-and-control (decision makers) who are not controlled by unseen "market forces" setting prices and quantities.

[89] *Id*. at 388 (quoting D.H. Robertson, Control of Industry 85 (1923)).

[90] Coase's explanation of the role of firms, which was a key reason he received the Nobel Prize, has spawned a huge literature in economics. For a summary of his contribution, *see* Ronald H. Coase, Prize Lecture: The Institutional Structure of Production at the Nobel Prize Banquet (Dec. 9, 1991)) (transcript available at https://www.nobelprize.org/prizes/economic-sciences/1991/coase/lecture/). As Coase notes, how things work within firms is still largely treated as a mysterious black box. Coase helped explain why firms exist, not how they function.

[91] Fethke & Policano, *supra* note 83, at 172 ("Research public universities can be characterized as federations of departments run by faculty who make key academic decisions with important financial implications."). In some disciplines, there are clear hierarchies of journals. In others, the hierarchies are less clear. Whether something like a patent "counts" for tenure and merit pay is also unclear. Universities that explicitly acknowledge the possibility that a patent would "count" in reviews (such as Texas A&M) appear to be relatively rare and even in those circumstances the weight to be put on a patent is often left to the department or the individual evaluators.

significant part of the reason why organization is more difficult but, as noted above, may also be a key to enabling a different type of research.

Moving a university toward commercialization is not an easy task. For example, Siegel, et al. found disagreements over whether start-ups should be encouraged at a particular university, where the vice president for research favored them, but a faculty member commented that "we need to stop pretending that academics can be entrepreneurs, or at least good ones." This signaled a need for university officials "to devote more time and effort to ensuring such goals permeate their institutions."[92] Getting those goals to "permeate" university culture is not simply a matter of adopting them – faculty skeptical of the role of commercialization need to be persuaded to participate and/or to not oppose participation by other faculty. The great variety in university research enabled by decentralized research interests can be an organizational strength, as it allows relatively unconstrained pursuit of creative ideas, but it also can make universities less easily focused than firms in pursuit of specific research goals.[93] The highly concentrated nature of university patenting described above suggests that relatively few universities or faculty see pursuit of commercializable intellectual property as particularly important.

Fourth, research within a university is done in pursuit of tenure and prestige (awards, job offers, publications, etc.) rather than in (or perhaps in addition to) pursuit of financial rewards.[94] Like everyone else, university-based researchers

[92] Donald S. Siegel et al., *Toward a Model of the Effective Transfer of Scientific Knowledge from Academicians to Practitioners: Qualitative Evidence from the Commercialization of University Technologies*, 21 J. Eng'g Tech. Mgmt. 115, 130 (2004).

[93] Universities, like corporations, are not monolithic. Organizational forms are created to further various interests. For example, Clemson University, not known for automotive expertise, agreed to establish an automotive research center as part of an effort by the state of South Carolina to attract BMW to build a plant. Its function is largely divorced from the main campus of the university. *See* Clemson Univ. Int'l Center for Auto. Rsch., https://cuicar.com/ (last visited Nov. 15, 2022).

[94] *See* Argyres & Liebeskind, *supra* note 79, at 431 (arguing that governance structures in universities "broadly reflect" commitment to open science); Edward B. Roberts & Donald H. Peters, *Commercial Innovation from University Faculty*, 10 Rsch. Pol'y 108, 118 (1981) (discussing results of faculty survey on motivations); *see also* Alice Lam, *What motivates academic scientists to engage in research commercialization: 'Gold', 'ribbon', or 'puzzle'?*, 40 Rsch. Pol'y 1354, 1357 (2011). Obviously, prestige comes to black box researchers too, such as Physics Nobel laureate Jack Kilby of Texas Instruments who was instrumental in developing the integrated circuit. However, cutting edge developments that may bring glory in academics, whether of any market value or not, is less likely to matter in corporate research.

generally prefer greater to lesser financial rewards, but they know most university-awarded financial rewards likely pale compared to those of their counterparts who pursue research in private industry. They thus clearly value the other attributes of universities over those of for-profit firms sufficiently enough to give up some financial rewards.[95]

Finally, universities can be difficult for outsiders to navigate because they operate so differently from firms.[96] Companies often complain about the problems of negotiating with universities.[97] (Academics also complain about companies' cultures.)[98] To bridge the gap, commentators have identified a "strong need for individuals who can act as intermediaries or boundary spanners" between universities and businesses.[99] As the president of the Maryland Technology Development Corporation testified, in support of the role of intermediary organizations like his, "the university culture is one of fairly complex and byzantine rules and regulations. Intermediaries help the entrepreneurs who have never even known the existence of tech transfer offices to understand what is going on, to help them understand what an express license is versus trying to negotiate on their own."[100] Universities' organizational complexity and differences from the private sector increases the cost of commercialization efforts, making outsiders less willing to work with universities. Mitigating these transaction costs is important

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[95] Bell Labs did not separately compensate researchers for their patents, instead paying them $1 on their first day for the rights to all future inventions. This did not bother at least some researchers. *See* Schroeder, *supra* note 54, at 68.

[96] *See* Dianne Rahm, *Academic Perceptions of University-Firm Technology Transfer*, 22 Pol'y Stud. J. 267, 267 (1994) ("Universities and firms have different missions, objectives, structures, organization cultures, and research orientations."). This was true of the corporate labs discussed above as well. *See also* Hiltzik, *supra* note 51, at xxii ("The scientists' unfettered creativity, not to mention their alien habits of mind and behavior, fomented unrelenting conflict with their stolid parent company.").

[97] *See* Virginia Gewin, *The Technology Trap*, 437 Science 948, 948 (2005); Argyres & Liebeskind, *supra* note 79, at 440-441; Siegel et. al, *supra* note 92, at 139.

[98] Siegel et. al, *supra* note 92, at 132.

[99] Donald S. Siegel, Mike Wright & Andy Lockett, *The Rise of Entrepreneurial Activity at Universities: Organizational and Societal Implications*, 16 Indus. & Corp. Change 489, 499 (2007); *see also* Donald S. Siegel, David Waldman & Albert Link, *Assessing the Impact of Organizational Practices on the Relative Productivity of University Technology Transfer Offices: An Exploratory Study*, 32 Rsch. Pol'y 27, 45 (2003) ("Without effective boundary spanning, the needs of customers may not be adequately communicated to suppliers.").

[100] H.R. Tech & Innovation Hearing, *supra* note 14, at 39 (statement of Robert Rosenbaum, President & Exec. Dir., Md. Tech. Dev. Corp.).

to try to expand commercialization efforts. However, such costs are desirable features, not bugs, for some in the university community. One example is the slower pace of decision making in universities due to shared governance; others include seemingly ever-expanding university bureaucracies that slow decision making. The slower pace or larger bureaucracies play important roles in securing support from constituencies within or important to universities.

In economic terms, we can think of the distinctive environment of universities as a series of constraints imposed on inventors' plans to connect their research outputs to the economy. These constraints are not present (although different ones are) in private firms. These constraints raise the transaction costs of doing business with a university.[101] But the constraints of university environments are not simply increased costs imposed by starry-eyed academics who fail to grasp the needs of the marketplace: The environment created in part by these constraints contains conditions for creativity that may enhance innovation. Firms – despite the many obstacles – contract with universities for research. This suggests the university environment offers something firms cannot buy elsewhere for a similar (or lower) price without incurring those transactions costs. In short, if universities were simply inefficient versions of the research environment that firms could create on their own, firms would have no need to contract with them. That firms contract with universities, faculty, and university-affiliated start-ups suggests that there is something valuable about the university environment and the researchers it attracts. This indicates that some research activities are best done through universities. One reason may be that universities are not just research laboratories: "[t]he differentiator for major research universities is the complementarity between teaching and research."[102] As we discuss below, there are reasons to think at least some universities may have a comparative advantage at some types of research.

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[101] Another major contribution of Ronald Coase to our understanding of organizational function arises from his discussion of what is referred to as transaction costs. That is, dealing with other people and other organizations involves cost—it is like friction that prevents the wonderful world of a perpetual motion machine. The worse the friction, the less efficient the machine. Making deals, even one-on-one, is costly. That friction, or transaction cost, may arise from differences in languages, location, and legal system. Coase provides an overview in his Nobel address of the consequences of "positive transaction costs" that originated in his article, *The Problem of Social Cost*, J. L. & ECON. 1 (1960).

[102] FETHKE & POLICANO, *supra* note 83, at 11.

C. Bayh-Dole & Incentives to Stimulate Research

Measuring research success is difficult. When a new idea is discovered, the future value is hard to know. Some inventions are not translated into success for some time and others, initially thought to be significant, fail to generate much revenue. One measure of university research output is the stock of inventions. In remarks on the Senate floor during debate over the 1980 Patent and Trademark Amendment Act, known as the Bayh-Dole Act after its cosponsors, Sens. Birch Bayh (D.-Ind.) and Robert Dole (R-Kan.),[103] Bayh described a relatively simple, linear model as the framework for the Act: "Hundreds of valuable medical, energy, and other technological discoveries are sitting unused under Government control, because the Government, which sponsored the research that led to the discoveries, lacks the resources necessary for development and marketing purposes, yet is unwilling to relinquish patent rights that would encourage and stimulate private industry to develop discoveries into products available to the public."[104] The notion of good ideas sitting on the shelf of agencies for lack of investment reflected part of the problem but neglected the full context within which the translation of ideas from the academy to the world could occur. As Terence Kealey, who served as both a scientist at Cambridge and vice chancellor of the University of Buckingham, observes, the linear model did not match reality during the industrial revolution or today.[105]

Universities, which capture some rewards, have more incentive to commercialize the results of research than government bureaucracies do, but, as discussed above, they operate under a wider set of constraints than Bayh's description suggested, which may help explain why so few successfully patent and transfer ideas. Moreover, "[t]he Act's emphasis on patenting and licensing as a critically important vehicle for the transfer to industry of academic inventions lacked a strong evidentiary foundation at the time of its passage, and evidence on the role of patenting and licensing as indispensable components of technology transfer remain mixed."[106] There are plenty of ideas "on the shelf" produced at research

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[103] 94 Stat. 3015 (codified at 35 U.S.C. §§ 200-212).

[104] 95 CONG. REC. S15,034 (Sept. 13, 1978). Similarly, one comment on Bayh-Dole summarized the issues as focused on "a race from discovery to commercialization with the university obtaining as much control over the invention as they can." Krumm, *supra* note 19, at 189.

[105] KEALEY, *supra* note 12, at 73.

[106] MOWERY ET AL., *supra* note 85, at 7-8.

universities but there are obstacles to getting them to the market for which Bayh-Dole's linear model does not account. The supply of ideas that might be commercialized is only a partial answer to why firms would license university-produced ideas or buy university-related firms.

University research generally produces what Schumpeter termed inventions, rather than innovations. The distinction is that inventions alone will not have an economic impact without the transformational genius of the entrepreneur. As Schumpeter noted,

> The inventor produces ideas, the entrepreneur 'gets things done,' which may but need not embody anything that is scientifically new. Moreover, an idea or scientific principle is not, by itself, of any importance for economic practice: the fact that Greek science had probably produced all that is necessary in order to construct a steam engine did not help the Greeks or Romans to build a steam engine; the fact that Leibnitz suggested the idea of the Suez Canal exerted no influence whatever on economic history for two hundred years.[107]

In Schumpeterian terms, what universities have to sell is just part of what is needed for an idea to succeed. To be useful in the marketplace, ideas must be manifested as designs, tools, methods, etc. that solve a problem or offer novelties previously unknown.[108]

Moreover, we need to keep in mind that licensing (or selling a firm with a license) is just one potential method of transferring knowledge from university to the market. As Litan, Mitchell, and Reedy argue,

> Universities have a range of outputs, including information, materials, equipment and instruments, human capital, networks, and prototypes. The means by which these outputs are diffused, especially to industry, vary across universities. The Carnegie Mellon Survey of Industrial R&D found that the most commonly reported mechanisms for diffusion of public research to industry were publications, conferences, and

[107] Schumpeter, *supra* note 32, at 224. Note that ideas alone cannot be patented.

[108] The scale of the investment needed to turn ideas into innovations was one reason that Schumpeter (inaccurately) forecast that innovation would become the province of only large businesses. *See* JOSEPH A. SCHUMPETER, CAPITALISM, SOCIALISM & DEMOCRACY 82 (1952).

> informal exchanges. Patents ranked low in most industries except for pharmaceuticals.[109]

Idea transfers from universities to the world can occur independently of commercialization. Faculty generate papers, teach, consult, serve on boards, and so on – all means of knowledge transfer.[110] Firms find value in these channels. A 2011 survey found the top two benefits reported by firms for interactions with universities were "access to fundamental understanding" and "access to direct assistance with problem solving."[111] An analysis of university strategies for interactions with firms therefore needs to incorporate channels besides commercialization. Over-estimates of the value of university-owned intellectual property can restrict faculty's ability to pursue other avenues while fruitless commercialization efforts are made. Nonetheless, Bayh-Dole was created because these other methods were thought insufficient.

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[109] Robert E. Litan et al., *Commercializing University Innovations: Alternative Approaches*, *in* 8 INNOVATION POL'Y & ECON. 31, 44 (Adam B. Jaffe, Josh Lerner & Scott Stern eds., 2008) (citations omitted). The other means include "nonpatent innovations, start-up companies launched by university faculty or related parties, and consulting engagements between industry and faculty." *Id*. Different faculty do different types of activities as well. *See* Agrawal & Henderson, *supra* note 80, at 47-52 (based on study of two departments at MIT). In addition, different firms collaborate with faculty on patents and papers. *Id*. at 52-58.

[110] Frank T. Rothaermel & Marie Thursby, *University-Incubator Firm Knowledge Flows: Assessing Their Impact on Incubator Firm Performance*, 34 RSCH. POL'Y 305, 318 (2005) (finding positive correlation in success with firm citation of papers); Valentina Tartari et al., *In Good Company: The Influence of Peers on Industry Engagement by Academic Scientists*, 43 RSCH. POL'Y 1189, 1201 (2014). There are likely other, relatively unexplored channels. Mathies and Slaughter explore the "executive science network" created by the overlap of private American Association of Universities ("AAU") member university and corporate boards and find connections for knowledge transfer. Charles Mathies & Sheila Slaughter, *University Trustees as Channels between Academe and Industry: Toward an Understanding of the Executive Science Network*, 42 RSCH. POL'Y 1286, 1296 (2013).

[111] Kate Bishop et al., *Gaining from Interactions with Universities: Multiple Methods for Nurturing Absorptive Capacity*, 40 RSCH. POL'Y 30, 37 (2011); *see also* Markus Perkmann et al, *Engaging Excellence? Effects of Faculty Quality on University Engagement with Industry*, 40 RSCH. POL'Y 539, 540-41 (2011) [hereinafter Perkmann et al., *Engaging Excellence*] (summarizing literature); Isabel Maria Bodas Freitas et al., *Finding the Right Partners: Institutional and Personal Modes of Governance of University-Industry Interactions*, 42 RSCH. POL'Y 50, 51 (2013) (finding evidence of an important channel of personal contractual relations with faculty in a sample of small Italian firms); Markus Perkmann, et al., *Academic Engagement and Commercialization: A Review of the Literature on University-Industry Relations*, 42 RSCH. POL'Y 423, 424 (2013) [hereinafter Perkmann et al.,*Academic Engagement & Commercialization*] ("[C]ommercialization is often an outcome or follow-on activity, whether intended or unintended, of academic engagement.").

As discussed earlier, treating universities like profit-maximizing firms is a major conceptual error.[112] Universities and firms operate under different legal and political constraints, actors within them face different incentives, and success is evaluated by different metrics both for the institutions and the researchers within them.[113] Pathways for discoveries to move from university research to commercial development must account for those differences. As Gulbrandsen, Mowery, and Feldman (leaders in the academic study of technology transfer from universities to firms) wrote in their introduction to a symposium, "a recognition of the heterogeneity in the characteristics of university–industry linkages among disciplines is crucial to the formulation of intelligent public policy and for more effective management by universities of their relationships with industry."[114] This is challenging as "[p]ractice without process becomes unmanageable, but process without practice damps out the creativity required for innovation; the two sides exist in perpetual tension. Only the most sophisticated and aware organizations are able to balance these countervailing forces in ways that lead to sustained creativity and long-run growth."[115]

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[112] Jensen et al., *supra* note 80, at 240 ("In a university setting, profit maximization is rarely the objective."). Former Harvard president, Derek Bok, argues that attempts to "make a profit from teaching, research, and other campus activities" are quite widespread in universities, have occurred over a long period, and are mostly different today in their "unprecedented size and scope." As a result, he contends "[e]ntrepreneurship is no longer the exclusive province of athletic departments and development offices; it has taken hold in science faculties, business schools, continuing education divisions, and other academic units across the campus." BOK, *supra* note 81, at 2-3. Bok uses the terms entrepreneurship and commercialization more broadly than did Schumpeter or does this Article; however his point is an important one. There are many efforts to find additional funding for universities – as Bok put it, "[t]hroughout the 1980s, deans and professors had brought me one proposition after another to exchange some piece or product of Harvard for money—often quite substantial sums of money." *Id.* at x. This phenomenon includes some amount of commercialization as discussed here but is a much broader set of issues.

[113] *See generally* RYAN AMACHER & ROGER MEINERS, FAULTY TOWERS (2004) (discussing some incentives within universities that are often a mystery to those not imbued in those institutions).

[114] Magnus Gulbrandsen, David Mowery, & Maryann Feldman, *Introduction to the Special Section: Heterogeneity and University-Industry Relations*, 40 RSCH. POL'Y 1, 5 (2011); *see also* Perkmann et al., *Engaging Excellence*, *supra* note 107 (discussing differences across disciplines in industry relationships).

[115] RICHARD FLORIDA, THE RISE OF THE CREATIVE CLASS, REVISITED 26-27 (2012). As Hoffman and Furcht noted, this idea is related to Michael Porter's idea that nations have clusters of related successful technologies. HOFFMAN & FURCHT, *supra* note 47, at 91 (quoting MICHAEL A. PORTER, THE COMPETITIVE ADVANTAGE OF NATIONS (1998), that "[n]ations succeed not in isolated industries, however, but in *clusters* of industries connected through vertical and horizontal relationships.").

If the fruits of university research are to make it to the marketplace, we need: (a) a variety of channels for the ideas to reach market actors, including means of commercialization, (b) a means of harnessing entrepreneurial talent from outside universities to innovations from within universities, and (c) methods that fit the unique environment within Coasian red boxes.

D. The University Environment & Innovation

As discussed above, the university environment differs from the environment of for-profit firms. The university is sometimes seen as the best environment for science, but not always.[116] Both entities, though, require innovators to navigate inefficient bureaucracies. Just as the university environment can be challenging, the for-profit environment can also be difficult for innovators as firms too can have inefficient bureaucracies.[117] At for-profit firms, innovators often struggle to adapt their method of project acceptance to the firm's formalized process, causing problems for the organization. As Griffin, et al. noted in their study of "serial innovators" in firms, "the way in which they navigate the politics of project acceptance are so different from the firm's formalized processes, they inherently cause problems for the organization."[118] Different incentive structures should mean that university researchers behave differently from researchers at for-profit firms. Although sarcastic, the account of a chemist hired away from academia by Dow Chemical in the 1920s (at twice his academic salary) in a letter to a friend written soon after the chemist started at Dow's research laboratory captures the difference:

> A week of the industrial slavery has already elapsed without breaking my proud spirit. Already I am so accustomed to the shackles that I scarcely notice them. Like the child laborers in the spinning factories and the coal mines, I arise before dawn and prepare myself a meager breakfast. Then

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[116] *But see* Myron S. Allen, *Working Procedures of Creativity*, *in* THE SECOND (1957) UNIVERSITY OF UTAH RESEARCH CONFERENCE ON THE IDENTIFICATION OF CREATIVE SCIENTIFIC TALENT 192, 194 (1957) ("when the need for creative scientists is so acute, why is an academic climate insisted upon in which creative thinking is inhibited, and in which a man is made to feel so uncomfortable if he exhibits originality?").

[117] ABBIE GRIFFIN ET AL., SERIAL INNOVATORS: HOW INDIVIDUALS CREATE AND DELIVER BREAKTHROUGH INNOVATIONS IN MATURE FIRMS 30 (2012) (Innovators in for-profit firms often find that "formal product development processes typically are insufficient to support breakthrough innovation," requiring them to "develop additional process capabilities over and above those already resident in the firm that nonetheless are compatible with existing processes.").

[118] *Id*. at 3.

> off to the terrific grind arriving at 8 just as the birds are beginning to wake up. Harvard was never like this.[119]

In this section we discuss research on creativity and innovation that helps understand why the university environment should be productive for at least some kinds of research.

First, innovation requires creativity.[120] As Richard Florida posits, creativity is "the faculty that enables us to derive useful new forms from knowledge."[121] Moreover, "creativity is often not just a single event or episode; it is sometimes an unplanned sequence of fortuitous events."[122] As a result, "creative success leads to further creativity, which helps to generate corporate funding to continue the work that initially did not appear to have potential—and frequently leads to business opportunities. . . . Working toward a goal can help creativity, but trying to predict or control the paths that link creative acts to useful results may do more harm than good."[123] It is thus a difficult force to control.

Second, we know that creativity is – contrary to popular perceptions of the lone genius toiling in a lab or studio[124] – "heavily dependent on social interaction,

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[119] William H. Starbuck, *How Organizations Channel Creativity*, *in* CREATIVE ACTION IN ORGANIZATIONS: IVORY TOWER VISIONS & REAL WORLD VOICES 106 (Cameron M. Ford & Dennis A. Gioia, eds., 1995).

[120] *See* Mihaly Csikszentmihalyi, *Society, Culture, and Person: A Systems View of Creativity*, *in* THE COLLECTED WORKS OF MIHALY CSIKSZENTMIHALYI 47 (2014) (arguing that innovation is the result of "three main shaping forces: a set of social institutions, or *field*, that selects from the variations produced by individuals those that are worth preserving; a stable cultural *domain* that will preserve and transmit the selected new ideas or forms to the following generations; and finally the *individual*, who brings about some change in the domain, a change that the field, will consider to be creative"). *See also* FLORIDA, THE RISE OF THE CREATIVE CLASS, *supra* note 115, at 88 ("'You cannot motivate the best people with money,' says Eric Raymond, author of *The Cathedral and the Bazaar* and a leading authority on open-source software. 'Money is just a way to keep score. The best people in any field are motivated by passion.'").

[121] FLORIDA, THE RISE OF THE CREATIVE CLASS, *supra* note 115, at 31. Florida points to Keith Simonton's definition of creativity as "the act of bringing something useful, that works, and is non-obvious into the world, or as he succinctly put it, that is the 'conjunction of novelty, utility, and surprise.'" *See supra* 115, at 6 (citing Keith Simonton, *Creativity: Cognitive, Developmental, Personal and Social Aspects*, 55 AM. PSYCHOLOGIST 151 (2000)).

[122] Walter L. Robb, *Membranes for Gas Separation: A Case Study in Creativity*, *in* CREATIVE ACTION IN ORGANIZATIONS: IVORY TOWER VISIONS & REAL WORLD VOICES 263 (Cameron M. Ford & Dennis A. Gioia, eds., 1995).

[123] *Id*. at 263.

[124] Mihaly Csikszentmihalyi & Keith Sawyer, *Creative Insight: The Social Dimension of a Solitary Moment*, *in* MIHALY CSIKSZENTMIHALYI, THE SYSTEMS MODEL OF CREATIVITY 74-75 (2014) ("When we look at the complete 'life span' of a creative insight in our subjects' experience, the moment of insight appears as

which takes the form of face-to-face encounters and of immersion in the symbolic system of one or more domains."[125] Matt Ridley sums it up as "a collective, incremental and messy network phenomenon" and "a team sport."[126] As one scientist reported during an interview on the creative process:

> Science is a very gregarious business; it's essentially the difference between having this door open and having it shut. If I'm doing science, I have the door open. That's kind of symbolic, but it's true. You want to be all the time talking with people…it's done by interacting with other people in the building that you get anything interesting done; it's essentially a communal enterprise.[127]

Part of their value is surely that at least some universities are places where such "gregarious business" is relatively easy to conduct.

Third, we know that "[t]he most significant insights (e.g., those that lead to innovative new products or uses for new technology) are often characterized by a synthesis of information from multiple domains, which can be as far apart as chemistry is from social norms, or as close as neighboring branches of

but one short flash in a complex, time-consuming, fundamentally social process. It is true that the individuals we interviewed generally report their insights as occurring in solitary moments: during a walk, while taking a shower, or while lying in bed just after waking. However, these reports are usually embedded within a more complex narrative, a story that describes the effort proceeding and following the insight, and the overall sense of these complete narratives stresses the salience of social, interactional factors. It seems that the solitary nature of the moment of insight may have blinded us to the social dimension of the entire creative process.").

[125] Mihaly Csikszentmihalyi & Keith Sawyer, *Shifting the Focus from Individual to Organizational Creativity*, *in* MIHALY CSIKSZENTMIHALYI, THE SYSTEMS MODEL OF CREATIVITY 70 (2014). *See also* Robb, *supra* note 122, at 263 ("creativity usually involves other people directly or indirectly, and sometimes they come from other departments or even outside the company; they bring divergent insights to bear on problems that converge on the interests of the company."); FLORIDA, THE RISE OF THE CREATIVE CLASS, *supra* note 115, at 118 ("Creativity involves the ability to synthesize."); Henry Eyring, *Scientific Creativity*, *in* THE SECOND (1957) UNIVERSITY OF UTAH RESEARCH CONFERENCE ON THE IDENTIFICATION OF CREATIVE SCIENTIFIC TALENT 159 (1957) ("The lone wolf has solved many problems, but an increasing number of scientific enterprises are becoming highly cooperative and require social integration. On team projects no degree of talent can fully compensate for an impossible personality inside the large scientific laboratories which are doing an ever-increasing proportion of the creative work of the world.").

[126] MATT RIDLEY, HOW INNOVATION WORKS AND WHY IT FLOURISHES IN FREEDOM 93, 256 (2020).

[127] Csikszentmihalyi & Sawyer, *Creative Insight: The Social Dimension of a Solitary Moment*, *supra* note 124, at 86.

mathematics."[128] Ridley refers to this as "ideas having sex,"[129] a metaphor that captures the environment in universities where 'DNA' from other fields is close at hand.

Fourth, there are "hot spots" as "access to the field is not evenly distributed in space. The centers that facilitate the realization of novel ideas are not necessarily the ones where the information is stored or where the stimulation is greatest."[130] These centers are "communities of practice" which are linked by "process and structure" to transfer knowledge, achieve scale, and generate growth.[131] This is well-illustrated by a scientist's description of the Berkeley chemistry department in 1930: "Successful research was the badge of honor. To not try to do research was unthinkable."[132] More broadly, Florida developed a theory to explain the success of cities due to the presence of a "creative class."[133] Although he focused on urban centers, he also contended that "Universities are the intellectual hubs of the creative economy. America's vital university system is the source of much of our

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[128] Csikszentmihalyi & Sawyer, *Shifting the Focus from Individual to Organizational Creativity*, *supra* note 125, at 70; *see also* Csikszentmihalyi & Sawyer, *Creative Insight: The Social Dimension of a Solitary Moment*, *supra* note 124, at 82 ("Revolutionary creative insights seem to be based on the random convergence of ideas from different domains, usually facilitated by interaction with individuals from different fields."); Matt Marx & David H. Hsu, *Revisiting the Entrepreneurial Commercialization of Academic Science: Evidence from 'Twin' Discoveries* 18 (Nat'l Bureau of Econ. Rsch. Working Paper No. 28203, 2020) (noting that interdisciplinary teams are more likely to commercialize).

[129] Ridley, *supra* note 126, at 251.

[130] Mihaly Csikszentmihalyi, Creativity: The Psychology of Discovery and Innovation 130 (1996). As Csikszentmihalyi notes, "Even with our dazzling electronic means for exchanging information, New York is still the best place for an aspiring artist to find out firsthand what's happening in the art world, what future trends other artists are talking about now. But New York is not the best place to learn oceanography, or economics, or astronomy. Iowa might be the best place to learn creative writing or etching, and one can learn things about neural networks in Pittsburgh that one cannot learn anywhere else." *Id. See also* Hoffman & Furcht, *supra* note 47, at 10-11 ("Even in an era of globalization, place matters for innovation. The world's cities and surrounding regions are where the lion's share of new scientific knowledge is produced and technical innovation is spawned. That has been true ever since the scientific revolution in Western Europe during the seventeenth century.").

[131] Florida, The Rise of the Creative Class, *supra* note 115, at 26-27. As Hoffman and Furcht noted, this idea is related to Michael Porter's idea that nations have clusters of related successful technologies. Hoffman & Furcht, *supra* note 47, at 91 (quoting Michael A. Porter, The Competitive Advantage of Nations (1998), that "Nations succeed not in isolated industries, however, but in clusters of industries connected through vertical and horizontal relationships.").

[132] Eyring, *supra* note 125, at 164.

[133] Richard Florida, The Flight of the Creative Class: The New Global Competition for Talent (2007).

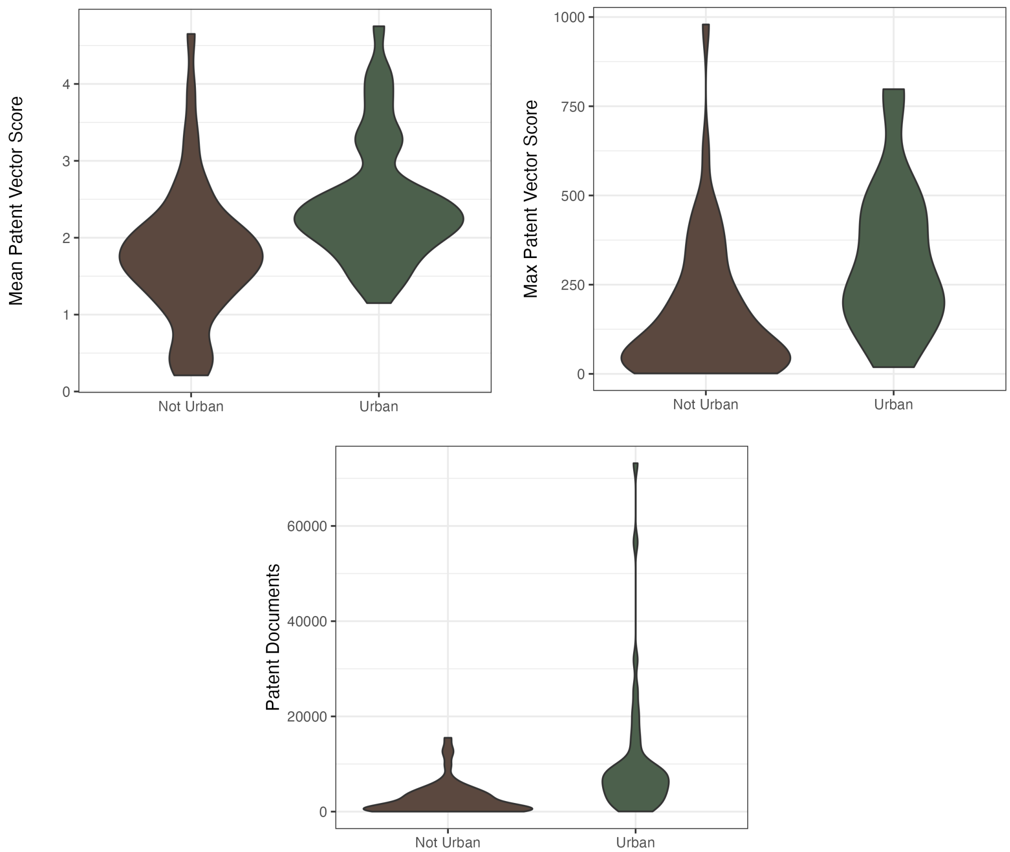
best scientific, social, and creative leadership." Because they promoted talent and tolerance, as well as research, they too drew a creative class.[134] These communities are also important because this is where tacit knowledge can be exchanged. Tacit knowledge plays an important role in transforming inventions into innovations.[135] Universities often build clusters of faculty with related interests, making them into 'hot spots' for those fields.

With our data, we find there is more high-value patent activity in universities in urban areas than those in non-urban areas, which might be due to an effect akin to Florida's "creative class" argument. Figure 4 shows the patent data broken down by urban/non-urban, with quite different patterns of patenting.

[134] *Id*. at 251.

[135] HOFFMAN & FURCHT, *supra* note 47, at 92 ("the tacit dimension of knowledge is intangible and highly local. It permeates the culture of clusters. The relationship between explicit and tacit knowledge may take the form of an equation: The more easily transferable codified knowledge is, the more valuable is the tacit form of knowledge. This is the location paradox and what Michael Porter means when he says that the more things are mobile, the more decisive location becomes.").

FIGURE 4:
URBAN V. NON-URBAN UNIVERSITIES



Although universities in non-urban areas, particularly large ones, create their own community of creative individuals, it may be that with respect to the specific types of creativity necessary to transform research into marketable intellectual property (a subset of entrepreneurial abilities), the lack of a sizeable urban center is problematic.

Fifth, individuals differ in creativity. Research suggests that individuals who have strong intrinsic motivation are more creative, and giving these individuals the freedom to explore ideas is also important.[136] People must also be curious

[136] Csikszentmihalyi & Sawyer, *Shifting the Focus from Individual to Organizational Creativity*, *supra* note 125, at 70-71 ("The most important individual characteristics are strong interest, curiosity, or intrinsic motivation that drive a person or group to commit attention to a — problematic area in a domain, and beyond generally accepted boundaries of knowledge."); *Id*. at 71 ("It is essential not to fill schedules with goal-directed, conscious, rational problem solving, so as to allow for the serendipitous combination of ideas.");

to be creative: "Without a good dose of curiosity, wonder, and interest in what things are like and in how they work, it is difficult to recognize an interesting problem."[137] They need to be able to engage in both divergent and convergent thinking[138] and be able to engage in the "hard work" that is "necessary to bring a novel idea to completion and to surmount the obstacles a creative person inevitably encounters."[139] Creative people have different powers of attention.[140] They also need to be able to discard bad ideas.

> Practically all creative individuals say that one advantage they have over their peers is that they can tell when their own ideas are bad, and that they can immediately forget the bad ideas without investing too much energy in them. Linus Pauling, the winner of two Nobel prizes, was asked at his sixtieth birthday party how he had been able to come up with so many epochal discoveries. "It's easy," he is said to have answered, "You think of a lot of ideas, and throw away the bad ones." To be able to do so, however, implies that one has a very strong internal representation of which ideas are good and which are bad–a representation that matches closely the one accepted by the field.[141]

David C. McClelland, *The Calculated Risk: An Aspect of Scientific Performance*, *in* THE 1955 UNIVERSITY OF UTAH RESEARCH CONFERENCE ON THE IDENTIFICATION OF CREATIVE SCIENTIFIC TALENT 96, 96 (1955) ("[V]ery often, when we are dealing with high-level scientific creativity, the real criterion is whether or not people create spontaneously whether they are asked to or not.").

[137] CSIKSZENTMIHALYI, CREATIVITY, *supra* note 130, at 53; *see also* J.P. Guilford, *The Relation of Intellectual Factors to Creative Thinking in Science*, *in* THE 1955 UNIVERSITY OF UTAH RESEARCH CONFERENCE ON THE IDENTIFICATION OF CREATIVE SCIENTIFIC TALENT 69, 72 (1955) ("Sensitivity to problems is an ability in which, in the writer's experience, there are gross differences among graduate students.").

[138] CSIKSZENTMIHALYI, CREATIVITY, *supra* note 130, at 60 ("Furthermore, people who bring about an acceptable novelty in a domain seem able to use well two opposite ways of thinking: the *convergent* and the *divergent*. Convergent thinking is measured by IQ tests, and it involves solving well-defined, rational problems that have one correct answer. Divergent thinking leads to no agreed-upon solution. It involves fluency, or the ability to generate a great quantity of ideas; flexibility, or the ability to switch from one perspective to another; and originality in picking unusual associations of ideas.").

[139] *Id*. at 61.

[140] *Id*. ("When asked what enabled him to solve the physics problems that made him famous, Hans Bethe answered with a smile: 'Two things are required. One is a brain. And the second is the willingness to spend long times in thinking, with a definite possibility that you come out with nothing.'").

[141] Mihaly Csikszentmihalyi, *Creativity and Genius: A Systems Perspective*, *in* MIHALY CSIKSZENTMIHALYI, THE SYSTEMS MODEL OF CREATIVITY 121 (2014).

Moreover, some people are better at identifying and solving problems that demand creative solutions, where "the nature of the problem to be solved is less clear; in fact, the problem itself might not be formulated until the moment of insight."[142] Identifying such problems is a key challenge.[143] If universities are better than firms at attracting individuals with these skills, then universities will have a comparative advantage in producing creative ideas. Further, the hiring of creative people is not something that ever ends: talent is not a stock but a flow.[144] Hiring processes must therefore focus on continually replenishing the flow. University hiring processes are generally driven by departments and so focused on excellence in particular fields, a focus which is likely to keep the flow moving.

Sixth, there must be an environment that fosters creativity for researchers,[145] a part of the analysis of creativity that has often been neglected.[146]

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[142] Csikszentmihalyi & Sawyer, *Creative Insight: The Social Dimension of a Solitary Moment*, *supra* note 124, at 79. This is the distinction between "presented problem solving" and "discovered problem finding." *Id*. The former occurs when "a problem is known and preexisting in the domain and all that needs to be focused is a solution to it." *Id*. The latter is what is discussed in the text. *See also* Csikszentmihalyi, Creativity, *supra* note 130, at 95 ("there are also situations in which nobody has asked the question yet, nobody even knows that there *is* a problem. In this case the creative person identifies both the problem and the solution. Here we have a 'discovered' problem.").

[143] Csikszentmihalyi, Creativity, *supra* note 130, at 95-96 (quoting Freeman Dyson that "It is characteristic of scientific life that it is easy when you have a problem to work on. The hard part is finding a problem to work on.").

[144] Florida, The Rise of the Creative Class, *supra* note 115, at 233 ("Most economists tend to see technology and talent as fixed stocks, like raw materials or natural resources, but the reality is that they are flows.").

[145] Karl G. Hill & Teresa M. Amabile, *A Social Psychological Perspective on Creativity: Intrinsic Motivation and Creativity in the Classroom and Workplace*, *in* Understanding and Recognizing Creativity: The Emergence of a Discipline (Scott G. Isaksen, Mary C. Murdock, Roger L. Firestien, & Donald J. Treffinger, eds.) 425 (1993) ("the individual's intrinsic motivation can be influenced not only by his own initial spark of interest in the task, but also by everything in the organization which might lead that initial interest to sputter away or to burn even more brightly."); Eyring, *supra* note 125, at 159 (""even the gifted individual requires a stimulating environment, including freedom from distractions which deflect attention from the question at issue and freedom from an authoritarian society which prevents unbiased enquiry.").

[146] Cameron M. Ford, *Creativity is a Mystery: Clues from Investigators' Notebooks*, *in* Creative Action in Organizations: Ivory Tower Visions & Real World Voices 21 (Cameron M. Ford & Dennis A. Gioia, eds., 1995) ("[T]his love affair with creators has led researchers to focus too narrowly on characteristics of individuals that lead them to commit creative acts. They have almost ignored the search for opportunities *when and where* creative acts are most likely to occur. This approach has certainly reduced the impact of creativity research in real-world settings. In organizational settings, this oversight is almost crippling. Organizations need not look so intently for heroes. Instead, we need to provide talented and motivated individuals with opportunities to enact creative solutions.").

> Based on what we now know about creativity, this is what managers should do to foster creativity in organizations. First, they should work to eliminate the environmental obstacles—the turf battles, the caustic reactions to new ideas, the lack of commitment to innovation. Second, they should create an environment where the stimulants are richly, redundantly present: an orientation toward innovation and risk taking, from the highest levels of top management on down; strategic direction for projects, coupled with procedural autonomy for those doing the projects; work that people perceive as challenging, interesting, and important; rewards and recognition for creativity; frequent, work-focused feedback; stimulating, diverse work teams; open communication and collaboration across the organization; and commitment of adequate resources and time for projects.[147]

While universities can be far from ideal in this regard, with disciplinary barriers, rigidity in existing conceptions of disciplines, and barriers to collaboration that range from the relatively mundane (parking) to deeply problematic (tenure standards that discourage cross-disciplinary work),[148] they can also be good places for creative work. One key advantage is that universities house smart, creative people from a variety of fields. This is important as a critical part of the creative process is interaction with people in "neighboring fields."[149]

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[147] Teresa M. Amabile, *Discovering the Unknowable, Managing the Unmanageable*, *in* Creative Action in Organizations: Ivory Tower Visions & Real World Voices 81 (Cameron M. Ford & Dennis A. Gioia, eds., 1995). This description echoes the descriptions of PARC, Bell Labs, and IBM Research discussed above.

[148] *See, e.g.*, Hoffman & Furcht, *supra* note 47, at 218 ("What is clear is that rigid institutional boundaries in hierarchal, tradition-bound universities and companies are inhibiting a more open flow of information to foster innovation in the pharmaceutical and biopharmaceutical arenas.").

[149] Csikszentmihalyi, *Society, Culture, and Person, supra* note 120, at 54 ("the model suggests that without people in neighboring fields who become attracted to the new idea, the creative process will be aborted. . . . In a setting with not enough mechanics interested in flying, the Wrights' efforts would eventually have been forgotten, and aeronautics would not have developed."); Csikszentmihalyi & Sawyer, *Creative Insight*, *supra* note 124, at 77 ("In our interviews, we found that creative individuals had a strong subjective awareness of external social or discipline influences at each creative stage. When asked to describe a moment of creative insight, they typically provided extended narratives that described not just a single moment but a complex, multi-stage process, with frequent discussions of interpersonal contact, strategic or political considerations, and awareness of the paradigm, of what questions were interesting as defined by the discipline. This was particularly salient in the preparation stage and in the evaluation and elaboration stage. Although the moment of creative insight usually occurs in isolation, it is surrounded and contextualized within an ongoing experience that is fundamentally social, and the insight would be, meaningless out of that context.").

The freedom of the university environment is also an important ingredient in this environment.[150] Indeed, Ridley says that freedom generally is the "secret sauce" that produces innovation: "[f]reedom to exchange, experiment, imagine, invest and fail; freedom from expropriation or restriction by chiefs, priests and thieves; freedom on the part of consumers to reward the innovations they like and reject the ones they do not."[151] This is not just the ability to choose an area of research but something broader. Creativity researchers identified "an environment where project goals are clear, challenging, and personally interesting, where they are given autonomy in deciding how to achieve project goals, where their new ideas are met with encouragement and enthusiasm, where they are not burdened with impossible project schedules or resource limitations" as important to fostering creativity.[152]

Finally, approaching the problem from the other end, Csikszentmihalyi and Sawyer argued that creativity is unlikely to be found where any of the following conditions are met:

- "The absence of a strong interest, curiosity, or intrinsic motivation that drives the person to commit attention to a problematic area in a domain. *A person who is not intrinsically motivated has no incentive to push beyond generally accepted boundaries of knowledge*.
- The absence of a thorough grounding in at least one symbolic domain, presumably as an apprentice to an expert, and not having experienced the colleagueship of other expert apprentices. *Creative insights typically involve the integration of perspectives from more than one domain*.
- The absence of interaction with other individuals who are experts in the domain or in potentially relevant other domains. *At every stage of the process,*

[150] Dennis A. Gioia, *Contrasts and Convergences in Creativity: Themes in Academic and Practitioner Views*, *in* Creative Action in Organizations: Ivory Tower Visions & Real World Voices 317, 328 (Cameron M. Ford & Dennis A. Gioia, eds., 1995) ("Traditional bureaucratic hierarchies are impediments to creativity. Organizational creativity often takes the form of creatively transforming the organization structure in ways that facilitate the activities of people looking for an opportunity to be creative.").

[151] Ridley, *supra* note 126, at 359.

[152] Hill & Amabile, *supra* note 145, at 425. *See also* Florida, the Rise of the Creative Class, *supra* note 115, at 107 ("You can't pump work out of creative people, assembly-line style. Motivating this kind of mental work requires a new kind of workplace—one that at the very least appears to be nurturing, attuned to individuality, and 'fun.'").

the stimulation and feedback of peers is necessary to select and evaluate potential insights.

- A schedule in which a person is always busy, goal-directed, involved in conscious, rational problem-solving. *Incubation is facilitated by periods of idling, leisure, and involvement in activities such as walking, gardening, driving* (i.e., activities that require some attention but are automated enough to permit subconscious processes to work just below the threshold level of awareness)."[153]

The barriers they describe are less likely to be present within universities. Universities thus have some comparative advantages in hiring people likely to produce creative solutions to problems. This provides an incentive for firms to harness that human capital to solve problems or to purchase the results of faculty research.

E. The Results of Innovation in Universities

Most university research falls into two of the types of innovation Schumpeter described in The Theory of Economic Growth: (1) "The introduction of a new good—that is one with which consumers are not yet familiar—or of a new quality of a good"; and (2) "The introduction of a new method of production, that is one not yet tested by experience in the branch of manufacture concerned."[154] These innovations require skills he attributes to entrepreneurs: "doing of new things or the doing of things that are already being done in a new way." There is considerable opportunity to do "new things" or do things "in a new way" as a result of university-related research. As a result of outside research funding, which grew substantially in the United States after World War II primarily from federal sources, university researchers sought to both help solve specific problems (produce new technologies for defense, etc.) and foster the development of basic science. This built on a

[153] Csikszentmihalyi & Sawyer, *Creative Insight: The Social Dimension of a Solitary Moment*, *supra* note 124, at 96.

[154] JOSEPH A. SCHUMPETER, THE THEORY OF ECONOMIC DEVELOPMENT 66 (Redvers Opie trans. 1983) (1934). The other three are: "[t]he opening of a new market, that is a market into which the particular branch of manufacture of the country in question has not previously entered, whether or not this market has existed before"; "[t]he conquest of a new source of supply of raw materials or half-manufactured goods, again irrespective of whether this source already exists or whether it has first to be created"; and "[t]he carrying out of a new organization of any industry, like the creation of a monopoly position (for example through trustification) or the breaking up of a monopoly position." *Id.*

tradition of public investment in practical research, starting with the Morrill Act and the creation of the land-grant university system.[155]

University researchers regularly make contributions to industry,[156] although as noted earlier, it is only a small minority of universities that do so. Such research is an important source of "key ideas" in many industries, "ideas that generate significant technological opportunities through fusion of knowledge of what's doable with knowledge of what needs to be done."[157] It also makes important indirect contributions from areas outside a given industry.[158] A survey of Advanced Technology Program projects suggested that industry invites universities into research projects that "involve what we have called 'new' science. Industrial research participants perceive that the university could provide research insight that is anticipatory of future research problems and that it could be an ombudsman anticipating and communicating to all parties the complexity of the research being undertaken."[159] Universities also produce inventions that "could not be developed independently by either the inventor or the firm."[160]

One differentiator for university-based research is that the results are generally "done" –from the point of view of the university – at an earlier stage than much

[155] 7 U.S.C. § 301 (1862). Agricultural research at land grant universities was the first large-scale targeted research project. It is not covered here as it generally operates outside the TTO model that can serve as a blanket covering research from a variety of research efforts at universities.

[156] Jerome H. Grossman et al., *Contributions of Academic Research to Industrial Performance in Five Industry Sectors*, 26 J. Tech. Transfer 143, 145 (2001) ("The breadth of research contributions have ranged from graduates trained in modern research techniques, to fundamental concepts and key ideas out of basic and applied research, to the development of tools, prototypes, and marketable products, processes, and services.").

[157] *Id*. at 146. *See also* Jeffery L. Furman & Megan J. MacGarvie, *Academic Science and the Birth of Industrial Research Laboratories in the U.S. Pharmaceutical Industry*, 63 J. Econ. Behav. & Org. 756 (2007).

[158] Grossman et al., *supra* note 156, at 146-147 ("Advances in information systems are critical to the technical and market performance of commercial aircraft and their components. Similarly, advances in medical devices, although occurring in the medical/life sciences sector, benefit strongly from developments in the mathematical and physical sciences and engineering. Computer-related technologies such as intelligent sensors, computer-aided diagnosis, and robotics flow into medical devices from other industry sectors.")

[159] The ATP, a program within the National Institute of Standards and Technology, is a combination of "public funds with private investments to create and apply generic technology needed to commercialize new technology rapidly." Bronwyn H. Hall et al., *Universities as Research Partners*, 85 Rev. Econ. & Stat. 485, 486, 491 (2003).

[160] Jensen & Thursby, *supra* note 80, at 242.

commercial research.[161] As Jensen and Thursby put it, "when they are licensed, most university inventions are little more than a 'proof of concept.'"[162] Early-stage results are less certain to become commercial products – that is, they carry greater uncertainty about both their technological and commercial potentials. They are riskier investments than ideas from later-stage research.[163] As a result, they are "fraught" with incentive problems and so are difficult to contract about. Licensing agreements are more time-consuming to conclude for early-stage status.[164] In brief, the investments needed to commercialize embryonic research from universities have three basic characteristics:

1. the investment is substantially sunk and is rarely recouped;
2. the technical and market uncertainties may diminish as information becomes available about the technology; and
3. the opportunity to invest is generally not completely dissipated by competition among rivals.[165]

These characteristics create incentives for market-driven investors to delay investments.[166] The slowness of development makes valuation difficult[167] and requires additional investment to bring products to the manufacturing stage.[168]

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[161] Litan et al., *supra* note 109, at 53 ("The majority of university-industry agreements relate to technologies that are many years away from being commercialized, and universities cannot take on the burden of forecasting uncertain commercial returns.").

[162] Jensen & Thursby, *supra* note 80, at 240. This occurs both because universities focus more on basic research than do firms and because academics have greater discretion to open up new inquiries.

[163] Hsu et al., *supra* note 15, at 6 (noting universities capture less of the value of patents in part because of the embryonic stage of the technologies they are commercializing).

[164] SCOTT SHANE, ACADEMIC ENTREPRENEURSHIP: UNIVERSITY SPINOFFS AND WEALTH CREATION 113-14, 122 (2004); *See* David H. Hsu & Tim Bernstein, *Managing the University Technology Licensing Process: Findings from Case Studies*, 9 J. ASS'N UNIV. TECH. MANAGERS 1(1997); Emmanuel Dechenaux, Jerry Thursby & Marie Thursby, *Inventor Moral Hazard in University Licensing: The Role of Contracts*, 40 RSCH. POL'Y 94, 102 (2011); *See* Jerry G. Thursby, Richard Jensen & Marie C. Thursby, *Objectives, Characteristics and Outcomes of University Licensing: A Survey of Major U.S. Universities*, 26 J. TECH. TRANSFER 59, 63 (2001). Trust between the parties is significant in being able to come to an agreement. Paul H. Jensen, Alfons Palangkaraya & Elizabeth Webster, Trust and the Market for Technology, 44 RSCH. POL'Y 340 (2015).

[165] Andrew A. Toole & Dirk Czarnitzki, *Biomedical Academic Entrepreneurship Through the SBIR Program*, 63 J. ECON. BEHAV. & ORG. 716, 720 (2007).

[166] *Id*. at 720.

[167] Clarysse et al., *supra* note 50, at 612.

[168] Jensen & Thursby, *supra* note 80, at 243.

Commercialization depends in large part on the university's ability to reduce commercial risk, which is more likely when there is a market "pull," the invention has become technically feasible, and production is predicted to be cost-effective.[169] As discussed below, these are difficult risks for early stage technologies.

What is missing from a university invention awaiting commercialization is what the entrepreneur brings to the table. As a result, connecting university research ideas to business partners is widely recognized as a critical step in enabling the ideas to have an impact. As one tech transfer expert put it, "if we can't get a commercial partner, those good ideas are going to sit on shelves."[170] Finance for development is a necessary but not sufficient part of the solution. As economist Fritz Machlup noted in his 1958 analysis of the patent system, the incentive provided by the patent monopoly generally is intended to motivate the additional investment to bring ideas to market: "Financing the work that leads to the making of an invention may be a relatively small venture compared with that of financing its introduction, because costly development work, experimentation in production and experimentation in marketing may be needed before the commercial exploitation of the invention can begin. The risks involved may be too great to be undertaken except under the shelter of a monopoly grant."[171] These risks are greater when much of the research comes from universities, due to the early stage of development. Giving patent rights to universities provides rewards long before much of the work is done, which is a potential problem with the Bayh-Dole model.

Moreover, a related major challenge with the ideas coming out of universities is that "new information tends to be produced in tacit form, increasing in tacitness as a function of distance from prior knowledge .... Tacit knowledge tends to be highly personal, initially known only by one person (or a small team of discovering scientists) and is difficult to transfer to others."[172] Universities do well at producing tacit knowledge that can be an advantage in commercialization because greater

[169] Yong Lee & Richard Gaertner, *Technology Transfer from University to Industry: A Large-Scale Experiment with Technology Development and Commercialization*, 22 Pol'y Stud. J. 384, 389 (1994).

[170] H.R. Tech & Innovation Hearing, *supra* note 14, at 49 (statement of Catherine Innes, Dir., Off. of Tech. Dev., Univ. of N.C. at Chapel Hill).

[171] Staff of Subcomm. on Pats., Trademarks & Copyrights of the S. Comm. on the Judiciary, 85th Cong., an Economic Review of the Patent System, at 36-37 (Comm. Print 1958).

[172] Lynne G. Zucker, Michael R. Darby & Jeff S. Armstrong, *Commercializing Knowledge: University Science, Knowledge Capture, and Firm Performance in Biotechnology*, 48 Mgmt. Sci. 138, 140 (2002).

tacitness offers greater opportunities by providing a firm with a competitive advantage.[173] However, greater tacitness also requires greater participation by faculty (who have the tacit knowledge) in further development of the research.[174]

F. The Challenge of Incentivizing University Invention

Some politicians saw the research produced in universities as a potential economic development tool. Through a combination of aligned interests and personality-based politics, the primary legal framework became vesting ownership of intellectual property rights arising from federally-funded research in universities via the Bayh-Dole Act.[175]

Bayh-Dole promised to unlock technological treasures that federal agencies funded but failed to push into the marketplace. By some measures, the statute is a success: it dramatically increased the number of patents awarded to universities, university-related start-up companies, and licenses from universities to outside entities for faculty-developed technologies.[176] In 2002, The Economist praised Bayh-Dole for creating incentives to invest private money "to turn a raw research idea into a marketable product" rather than allowing ideas of university researchers to be left "in warehouses gathering dust."[177] The then-director of the Wisconsin Alumni Research Foundation, the oldest and one of the most successful of the entities focused on commercializing university research, praised it for stimulating partnerships between government, universities, and start-up firms, and claimed that almost a third of the value of the NASDAQ (in 2007) came from university-

[173] *Id*. at 141-42.

[174] *Id*. at 151.

[175] *See* Stevens, *supra* note 5 (describing the personality-driven politics of the statute's passage).

[176] There is some dispute over the impact of Bayh-Dole. Coupé argues that the evidence points to the establishment of a TTO as the key in increasing patents, although he notes that the statute may have motivated the creation of TTOs. Tom Coupé, *Science is Golden: Academic R&D and University Patents*, 28 J. Tech. Transfer 31, 43 (2003). *See also* Rebecca Henderson, Adam B. Jaffe & Manuel Trajtenberg, *Universities as a Source of Commercial Technology: A Detailed Analysis of University Patenting, 1965-1988*, 80 Rev. Econ. & Stat. 119, 121-22 (1998) (noting difficulty in disentangling Bayh-Dole, TTO formation, and increased industry funding for research due to simultaneity); Mowery & Sampat, *supra* note 5, at 120 ("there is no evidence of a structural break in trends in patent propensity after Bayh-Dole."); David C. Mowery, Richard R. Nelson, Bhaven N. Sampat & Arvids A. Ziedonis, *The growth of patenting and licensing by U.S. universities: an assessment of the effects of the Bayh-Dole act of 1980*, 30 Rsch. Pol'y 99, 116 (2001) ("Bayh-Dole, while important, was not determinative.").

[177] *Innovation's Golden Goose*, The Economist (Dec. 14, 2002), https://www.economist.com/technology-quarterly/2002/12/14/innovations-golden-goose.

based, federally-funded research.[178] Further, an evaluation of time-to-market found a faster translation of research to market in 1986-1994 relative to 1975-1984, which could reflect improved commercialization or greater emphasis on applied research by universities.[179] Not everyone sees the statute as a complete success: some studies of the value of the increased patents concluded that average quality was lower due in part to increased patenting of "losers"—patents that receive zero subsequent citations.[180]

Bayh-Dole's approach, and the claims made for it, focus on the development potential of inventions stuck behind a wall of federal red tape combined with a more straightforward model of how research investments could turn ideas into marketable products. This approach neglects the Schumpeterian insight that this is not a linear or simple process. We need to appreciate "how multiple, unevenly paced, and nonlinear are the paths between scientific discovery and new technology."[181] What is needed is not just investment (although often quite a lot is needed) but what Schumpeter called the "creative response." He distinguished that from the managerial "adaptive response" in three ways:

> First, from the standpoint of the observer who is in full possession of all relevant facts, it can always be understood *ex-post*; but it can practically never be understood *ex-ante*; that is to say, it cannot be predicted by applying the ordinary rules of inference from the pre-existing facts. This is why the 'how' in what has been called above the 'mechanisms' must be investigated in each case. Secondly, creative response shapes the whole course of subsequent events and their 'long-run' outcome. . . . Creative response changes social and economic situations for good, or, to put it differently, creates situations from which there is no bridge to those situations that might have emerged in its absence. That is why

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[178] Carl E. Gulbrandsen, *Bayh-Dole: Wisconsin Roots and Inspired Public Policy*, 2007 Wis. L. Rev. 1149, 1151 (2007).

[179] Edwin Mansfield, *Academic Research and Industrial Innovation: An Update of Empirical Findings*, 26 Rsch. Pol'y 773, 774 (1998).

[180] Henderson, Jaffe, & Trajtenberg, *supra* note 176, at 126 (decline); Bhaven N. Sampat, David C. Mowery, & Arvids Ziedonis, *Changes in University Patent Quality after the Bayh-Dole Act: A Reexamination*, 21 Int'l J. Ind. Org. 1371 (2003) (no decline). *See also* J.B. Powers & P. McDougall, *Policy Orientation Effects on Performance with Licensing to Start-ups and Small Companies*, 34 Rsch. Pol'y 1028, 1030 (2005) [hereinafter Powers & McDougall, *Policy Orientation*].

[181] Stokes, *supra* note 2, at 75.

> creative response is an essential element in the historical process; no deterministic credo avails against it. Thirdly, creative response—the frequency of its occurrence in a group, its intensity and success or failure—has something, be that too much or little, to do (a) with quality of the personnel available in a society, (b) with relative quality of personnel, that is, with quality available to a particular field of activity relative to quality available at the same time, to others, and (c) with individual decisions, actions, and patterns of behavior. Accordingly, a study of creative response in business becomes coterminous with a study of entrepreneurship. The mechanisms of economic change in capitalist society pivot on entrepreneurial activity.[182]

We argue that university researchers often produced research results that were candidates for leading to a "new thing" or a "new way of doing things" *because* conditions gave university-based researchers more freedom in their research. However, this boost to creating good ideas was not without its costs. This enhanced potential makes translating the idea into the marketplace a greater challenge because the research demands financial investment, additional intellectual development, and, crucially, entrepreneurial talent to make that transition. Such investments require costly contracting to accomplish, given the early stage of most university-connected ideas. Such contracting is difficult for universities reliant on general counsel offices that lack sophisticated IP legal talent in the private sector.[183]

The most difficult input is entrepreneurial talent. Schumpeter thought entrepreneurial skills were in short supply: "It is in most cases only one man or a few men who see the new possibility and are able to cope with the resistances and difficulties which action always meets with outside of the ruts of established practice."[184] The challenge for universities wishing to see researchers' ideas take

[182] Schumpeter, *Creative Response*, *supra* note 32, at 222.

[183] For example, hiring outside IP counsel at Texas A&M requires selecting firms from a pre-approved list (approved by both the Texas Attorney General and the Texas A&M System Office of General Counsel). Firms must apply to be on the approved list, which is opened only every two years. Even with the best of intentions and thoughtful, apolitical screening of firms, this still imposes a hurdle that private sector firms do not face in choosing IP counsel.

[184] Schumpeter, *Creative Response*, *supra* note 32, at 224.

root in the economy is to find how to connect the opportunity an idea offers with financial capital and entrepreneurial skill.

II
How Universities Commercialize Research

Universities have changed how they approach research commercialization as a result of Bayh-Dole. Understanding this helps us assess the current process and how it might be improved, as well as understanding the impact of recent changes to universities.

A. *The Institutional Context*

Formal university commercialization efforts started with the University of Wisconsin's rejection of a faculty member's offer of an invention to the university based on legal advice that the university could not spend state resources on patenting an idea. Prof. Harry Steenbock then created the Wisconsin Alumni Research Foundation (WARF) and assigned his invention (a way to increase the vitamin D content of food) to it in 1925. The invention was a success and WARF brought in millions of dollars.[185] WARF later pioneered agreements with the federal government allowing Wisconsin to take title to patents based on research funded by agencies.[186] That success served as a model for the Bayh-Dole Act.[187]

Among the goals of Bayh-Dole were to reduce the complexity would-be commercializers faced in dealing with agency licensing procedures, to clarify who held rights to patents, and to place ownership where there would be an incentive to license.[188] University patenting increased dramatically.[189] The number of TTOs increased from 25 at the time the statute was passed to 3,300 twenty-five years

[185] Gulbrandsen, *supra* note 178, at 1156.
[186] *Id*. at 1157.
[187] *Id*.
[188] *See* Daniel E. Stern, *Stalled Patents: Re-Incentivizing Universities to Review Their Portfolios of Unlicensed Patents to Achieve the Bayh-Dole Act's Unfunded Mandate*, 45 Hofstra L. Rev. 1017, 1027-28 (2017).
[189] Charles R. McManis & Brian Yagi, *The Bayh-Dole Act and the Anticommons Hypothesis: Round Three*, 21 Geo. Mason L. Rev. 1049, 1057 (2014). Some have suggested that universities routinely patent technologies that prove to have no commercial value, responding to faculty demand for patents. *See generally* Lorelei Ritchie de Larena, *The Price of Progress: Are Universities Adding to the Cost?*, 43 Houston L. Rev. 1373, 1422 (2007).

later.[190] As Litan, Mitchell, and Reedy noted, TTOs "were the product—more than likely the *unintended consequence* of" Bayh-Dole.[191]

AUTM, formerly the Association of University Technology Managers, which has an interest in portraying the outcome of Bayh-Dole as favorable, estimated in 1999 that academic licensing of technologies led to $33 billion in economic activity and 280,000 jobs in the United States.[192] A study commissioned by the National Academy of Engineering more modestly claimed that the impact of academic research on the medical device, financial services, and network systems and communications industry had been "large" and the impact on the transportation, distribution, and logistics and aerospace industries had been "moderate."[193] There is evidence that faculty entrepreneurs are highly cited and productive, suggesting that entrepreneurial activity need not reduce academic achievement.[194] However, the effects differ across fields.[195]

[190] de Larena, *supra* note 189, at 1412. That includes TTOs at hospitals and other non-university research entities that may compete for federal funds. Another measure is the rapid increase in membership in the Association of University Technology Managers, which went from under 100 in 1980 to over 2,000 in 1998. Siegel et al., *supra* note 92, at 116.

[191] Litan et al., *supra* note 109, at 41.

[192] AUTM, AUTM Licensing Survey: FY 1998. Unsurprisingly, perhaps, university tech transfer offices report they are understaffed. Scott Shane, Academic Entrepreneurship: University Spinoffs and Wealth Creation (2004).

[193] Grossman et al., *supra* note 156, at 148.

[194] Robert A. Lowe & Claudia Gonzalez-Brambila, *Faculty Entrepreneurs and Research Productivity: A First Look*, 32 J. Tech. Transfer 173, 189 (2007) ("[E]ntrepreneurs are more likely to be among the most highly cited researchers in their field than control samples and the population of science and engineering faculty at the universities in our study" but highly cited entrepreneurs are still "a minority among all entrepreneurs."); *see also* Karen Seashore Louis, David Blumenthal, Michael E. Gluck & Michael A. Soto, *Entrepreneurs in Academe: An Exploration of Behaviors Among Life Scientists*, 34 Admin. Sci. Q. 110, 127 (1989) ("[S]cientifically productive scholars are more entrepreneurial on several dimensions."); Siegel et al., *supra* note 92, at 132; Bart Clarysse, Valentina Tartari & Ammon Salter, *The Impact of Entrepreneurial Capacity, Experience and Organizational Support on Academic Entrepreneurship*, 40 Rsch. Pol'y 1084, 1092 (2011) ("[A]cademic excellence, reputation and entrepreneurial activity go hand-in-hand.").

[195] Lowe & Gonzalez-Brambila, *supra* note 194, at 189.

Bayh-Dole spurred a focus on patenting by universities.[196] This alone may be a benefit of the statute, even with respect to traditional views of the role of the university, as some research suggests patents are a reaffirmation of the originality of a scientist's work.[197] Azoulay, Ding, and Stuart argue that "patents and publications correspond to two types of output that have more in common than previously believed" and "encode similar pieces of knowledge."[198] Agrawal and Henderson's study of two MIT departments found considerable differences between publications and patents.[199] Specifically, faculty who patented also published work with more impact. Similarly, Magerman, Van Looy, and Debackere analyzed biotechnology patent-paper pairs and found no negative citation effects associated with patents.[200] Papers associated with a patent received more citations, leading them to conclude that "patenting does not jeopardize one's scientific footprint."[201] Patent rights may be "necessary to drive commercialization, particularly in the biomedical context," because turning an idea into a product requires large investments.[202]

Fans of the statute argue that it gives university researchers an incentive to push ideas into the marketplace, enabling them, and society, to reap the rewards that come with patent licensing.[203] Hellman suggests a model that yields a

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196 Richard R. Nelson, *Observations on the Post-Bayh-Dole Rise of Patenting at American Universities*, 26 J. Tech. Transfer 13, 13-14 (2001). It was not just Bayh-Dole that prompted the dramatic increase in patenting and licensing by universities. Nelson argues it was also due to the rise of biotechnology, "where research results often seem to promise significant commercial value down the road." *Id*. at 14. Nelson also attributes some of the rise to overall strengthening of IP rights in the United States. *Id*.

197 Jason Owen-Smith & Walter W. Powell, *To Patent or Not: Faculty Decisions and Institutional Success at Technology Transfer*, 26 J. Tech. Transfer 99, 108 (2001).

198 Pierre Azoulay et al., *The determinants of faculty patenting behavior: Demographics or opportunities?*, 63 J. Econ. Behav. & Org. 599, 621 (2007).

199 Agrawal & Henderson, *supra* note 80, at 77.

200 Tom Magerman, Bart Van Looy & Koenraad Debackere, *Does Involvement in Patenting Jeopardize One's Academic Footprint? An Analysis of Patent-Paper Pairs in Biotechnology*, 44 Rsch. Pol'y 1702, 1709 (2015). A study of UK academics found that above a certain point, increased patenting did become a substitute for both publishing and interaction with firms. Gustavo Crespi, Pablo D'Este, Roberto Fontana & Aldo Geuna, *The Impact of Academic Patenting on University Research and Its Transfer*, 40 Rsch. Pol'y 55, 65 (2011).

201 Azoulay et al., *supra* note 198, at 621; Agrawal & Henderson, *supra* note 80, at 59. *See also* Guilford, *supra* note 137, at 83 (quoting a comment by a seminar participant that productivity is the rule rather than the exception for people who produce valid and original ideas: "If you produce one, you're very likely to produce a lot.").

202 Ian Ayres & Lisa Larrimore Ouellette, *A Market Test for Bayh-Dole Patents*, 102 Cornell L. Rev. 271, 277 (2017).

203 Birch Bay & Joseph P. Allen, *Our bipartisan bid to spur medical research still bearing fruit after 35 years*, Stat (Dec. 9, 2015) available at https://www.statnews.com/2015/12/09/medical-research-bayh-dole/

"science to market gap" in which firms are unaware of what scientific discoveries might meet their needs.[204] This is bridged by communication between researchers and firms–which is encouraged by patenting's incentive to researchers to push discoveries out to industry–with TTOs serving as the agents.[205] How much this has succeeded is not clear, although data on university patents suggests it has not succeeded outside of a small subset of universities: one report suggested that 95 percent of university patents are unlicensed.[206] If true, this signals a weakness in either (or both) the process or the value of the research pursued.

Not everyone cheers the focus on intellectual property, commercialization and the creation of TTOs. Critics challenge the reliance on exclusivity in licensing. Nelson argues that companies are willing to invest without exclusive rights to university-developed research because they anticipate being able to patent their own improvements and so reap rewards.[207] Others raise concerns that increased patenting based on university research leads to an "anti-commons" in which a patent thicket slows or blocks future research.[208] Empirical research suggests there is little evidence that patent licensing blocks research (in part because academic researchers often ignore patents) but there is evidence that materials and data access agreements pose problems.[209] Eisenberg, one of the main proponents of the anti-commons interpretation, explained this to be the result of the high transaction costs

("The law has become a recognized best practice adopted by many countries to integrate university research into their economic development efforts.").

[204] Thomas Hellmann, *The Role of Patents for Bridging the Science to Market Gap*, 63 J. ECON. BEHAV. & ORG. 624 (2007); *see also* Siegel et al., *supra* note 92, at 130 (elaborating on role of TTO as bridge).

[205] *Id.*

[206] Heidi Ledford, *Universities Struggle to Make Patents Pay*, 501 NATURE 471, 472 (2013). A 1995 NSF survey showed higher rates of conversion of patents into grants and commercialized products for scientists and engineers in industry than for those in education (three in ten versus one in five). Robert P. Morgan, Carlos Kruytbosch & Nirmala Kannankutty, *Patenting and Invention Activity of U.S. Scientists and Engineers in the Academic Sector: Comparisons with Industry*, 26 J. TECH. TRANSFER 173, 178 (2001). *But see* Daniel W. Elfenbein, *Publications, Patents, and the Market for University Inventions*, 63 J. ECON. BEHAV. & ORG. 688, 713 (2007) (describing study of Harvard's inventor disclosures over several decades which found that the grant of a patent significantly increased the likelihood that a license partner would later be found, especially for less experienced inventors).

[207] Nelson, *supra* note 196, at 16.

[208] *See, e.g.*, Michael A. Heller & Rebecca S. Eisenberg, *Can Patents Deter Innovation? The Anticommons in Biomedical Research*, 280 SCIENCE 698 (1998); *see also* Nelson, *supra* note 196, at 18 (arguing against patenting fundamental research results and techniques).

[209] Rebecca S. Eisenberg, *Noncompliance, Nonenforcement, Nonproblem? Rethinking the Anticommons in Biomedical Research*, 45 HOUS. L. REV. 1059, 1098 (2008).

of enforcing patents against researchers and the low transaction costs of denying researchers access to materials and data unless they agreed to restrictions on use.[210]

Other critics raise concerns about universities using patents "not for purposes of fostering commercialization, but instead to extract rents in apparent holdup litigation."[211] Some argue that university TTOs focus on short-term 'lottery' patents to get the quickest payback, over long-term investments in ideas that may have greater potential.[212] Others claim that a focus on commercialization steers universities away from their proper role in society,[213] and some contend that commercialization prioritizes applied research over the traditional goal of pure knowledge.[214] Some are concerned that commercialization will restrict communication among scientists.[215] The NAE study cautioned that

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[210] Eisenberg, *supra* note 209, at 1098-99. There is some evidence that patenting reduces future citations (at least, in the life sciences), suggesting there may be some anti-commons effect. Fiona Murray & Scott Stern, *Do Formal Intellectual Property Rights Hinder the Free Flow of Scientific Knowledge? An Empirical Test of the Anti-Commons Hypothesis*, 63 J. ECON. BEHAV. & ORG. 648, 683-84 (2007). In addition, suits against state universities must overcome Eleventh Amendment sovereign immunity issues.

[211] Arti K. Rai, John R. Allison & Bhaven N. Sampat, *University Software Ownership and Litigation: A First Examination*, 87 N.C. L. REV. 1519, 1519 (2009).

[212] Litan et al., *supra* note 109, at 43. Patent litigation over university IP can disrupt TTO operations by taking "time and attention of licensing officers away from . . . marketing, search, and negotiation activities" and can crowd out some licensing activity. Scott Shane & Deepak Somaya, *The Effects of Patent Litigation on University Licensing Efforts*, 63 J. ECON. BEHAV. & ORG. 739, 741 (2007). In a survey of university patent offices, Shane and Somaya found that the office directors "were unanimous that university-led patent litigation caused significant dislocation in the operation of the technology licensing office," both through the time demands on office personnel and due to the stress and morale impacts on staff. *Id*. at 746. Shane and Somaya's data bear this out, showing a drop in licensing while litigation is underway. *Id*. at 750.

[213] A prominent such critic is Jennifer Washburn; *see* JENNIFER WASHBURN, UNIVERSITY, INC.: THE CORPORATE CORRUPTION OF AMERICAN HIGHER EDUCATION (2005); *see also* Mark A. Lemley, *Are Universities Patent Trolls?*, 18 FORDHAM INTELL. PROP. MEDIA & ENT. L.J. 611, 625 (2008); Siegel, Wright & Lockett, *supra* note 99, at 497 ("There is an inherent conflict of interest between the traditional academic reward system, which is focused on peer reviewed publication of basic research, and the technology transfer reward system. . . ."); G.R. Evans & D.E. Packham, *Ethical Issues at the University-Industry Interface: A Way Forward?*, 9 SCI. & ENG'G ETHICS 3, 8 (2003); James J. Duderstadt, *Commercialization of the Academy: Seeking a Balance Between the Marketplace and Public Interest*, SAM NUNN POL'Y F. (2002), http://milproj.dc.umich.edu/publications/academy_comercialization/download/academic_commercialization.pdf; Donald Kennedy, ACADEMIC DUTY (Harvard Univ. Press 1997).

[214] Dovid A. Kanarfogel, *Rectifying the Missing Costs of University Patent Practices: Addressing Bayh-Dole Criticisms Through Faculty Involvement*, 27 CARDOZO ARTS & ENT. L.J. 533, 544-45 (2009).

[215] Larsen, *supra* note 18, at 9. *But see* Carolin Haeussler, *Information-Sharing in Academia and the Industry: A Comparative Study*, 40 RSCH. POL'Y 105, 117 (2011) (finding few differences in information sharing between those involved in commercialization and those not).

commercialization efforts raise questions about whether "the entrepreneurial university and the new interest in financial gain are distorting the traditional values, goals, and the identity of the university with negative consequences."[216] These concerns are not merely rhetorical: there is evidence that publications associated with patents lead to slower rates of forward citations.[217] Backward citations in industrial patents are increasing as university patenting increases, suggesting "a slowdown in the pace of firm knowledge exploitation."[218]

Commercialization may be beyond the ability of universities. They may not be able "to adapt to, to articulate, and to pursue new directions in basic and applied research and training" to keep up with industry needs "while continuing to jump-start new areas of basic, long-term research and generate the key ideas that will provide the foundation for tomorrow's industries."[219] More generally, Bayh-Dole has been criticized as a "poorly targeted institution" because intellectual property rights are "a blunt and costly mechanism for facilitating technology transfer from the government to industry when compared to alternatives."[220]

There seems to be little empirical support for the sharpest criticism of university focus on TTOs and commercialization.[221] There is evidence that licensing has *not* shifted university research away from basic research and that licensing promotes additional basic research.[222] Azoulay, Ding, and Stuart found that "patenting is often accompanied by a flurry of publication activity in the year preceding the patent application, even after accounting for the lagged stock of publications" and, controlling for scientist-fixed effects, suggest that "surges

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[216] Grossman et al., *supra* note 156, at 150; *see also* Etzkowitz, Quasi-Firms, *supra* note 13, at 116-17.

[217] *See* McManis & Yagi, *supra* note 189, at 1065.

[218] McManis & Yagi, *supra* note 189, at 1068; Kira R. Fabrizio, *University Patenting and the Pace of Industrial Innovation*, 16 INDUS. & CORP. CHANGE 505, 521 (2007).

[219] Grossman et al., *supra* note 156, at 150.

[220] Brett Frischmann, *Innovation and Institutions: Rethinking the Economics of U.S. Science and Technology Policy*, 24 VT. L. REV. 347, 352 (2000).

[221] Rosa Grimaldi et al., *30 Years After Bayh-Dole: Reassessing Academic Entrepreneurship*, 40 RSCH. POL'Y 1045, 1046 (2011) ("Academic research has found little systematic evidence of a destruction of the open culture of science or to support the assertion that universities are performing less basic research.").

[222] Jerry G. Thursby & Marie C. Thursby, *Has the Bayh-Dole Act Compromised Basic Research?*, 40 RSCH. POL'Y 1077, 1083 (2011); Jerry G. Thursby & Marie C. Thursby, *University Licensing: Harnessing or Tarnishing Faculty Research?*, 10 INNOVATION POL'Y & ECON. 159, 159 (2010); Jerry G. Thursby & Marie C. Thursby, *Who is Selling the Ivory Tower? Sources of Growth in University Licensing*, 48 MGMT. SCI. 90, 102 (2002).

of scientific productivity, not steady research performance, is most likely to be associated with patenting," a finding they interpret to mean that "uncovering of new, productive areas of scientific inquiry is an important precursor to the act of patenting."[223] They also found a relationship between what they term the "latent patentability" of faculty research and the propensity to patent, having derived the former from a keyword analysis of publications of scientists already patenting in the same area.[224] Thursby and Thursby found recent disclosure activity had an overall positive impact on both public and private faculty research funding and publication rates.[225]

Much of the university interest is, of course, about money. A 2000 review of the literature on university-industry partnerships found that university motivations were "largely financially based" while industry motivations focused on "access to complementary research activity and research results" and "access to key university personnel."[226] Despite the creation of many TTOs, commercialization efforts did not produce a financial windfall, which is unsurprising when we take into account how few universities are patenting extensively or patenting high value ideas. Reinforcing our conclusions from the patent data, one study of 2012 data found 130 of the 155 universities reporting data did not cover expenses for the year.[227] Another concluded that "[v]ery few university 'inventions' garner significant

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[223] Azoulay et al., *supra* note 198, at 600.

[224] *Id*.

[225] Jerry G. Thursby & Marie C. Thursby, *Faculty Participation in Licensing: Implications for Research*, 40 Rsch. Pol'y 20, 29 (2011).

[226] Hall et al., *supra* note 159, at 486; *see also* Jerry G. Thursby, Richard Jensen & Marie C. Thursby, *Objectives, Characteristics and Outcomes of University Licensing: A Survey of Major U.S. Universities*, 26 J. Tech. Transfer 59, 65 (2001); Joseph Friedman & Jonathan Silberman, *University Technology Transfer: Do Incentives, Management, and Location Matter?*, 28 J. Tech. Transfer 17, 18-19 (2003) (summarizing surveys); Jensen & Thursby, *supra* note 80, at 245 (explaining that TTO staff perceive university administrators to believe licensing revenue is top goal).

[227] Walter D. Valdivia, University Start-Ups: Critical for Improving Technology Transfer 9 (2013), https://www.brookings.edu/wp-content/uploads/2016/06/Valdivia_Tech-Transfer_v29_No-Embargo.pdf; *see also* Rebecca S. Eisenberg, *Public Research and Private Development: Patents and Technology Transfer in Government-Sponsored Research*, 82 Va. L. Rev. 1663, 1713 (1996) (concluding from analysis of 1990s data that universities are not making large profits above costs); P. Conceição et al., *University-Based Technology Licensing in the Knowledge Based Economy*, 18 Technovation 615, 618 (1998) (predicting licensing revenue at most schools will"remain small"); Bok, *supra* note 81, at 77 ("The financial results are reminiscent of intercollegiate athletics. Most universities have not earned much money from royalties; the odds of making anything substantial from patenting a new discovery are extremely small.").

license incomes. . . . Many universities are [likely] paying significantly more to run their patenting and licensing offices than they are bringing in license revenues."[228] One survey found that the top five inventions licensed by each university accounted for 78 percent of gross licensing revenue.[229] Litan, Mitchell, and Reedy concluded that "[t]his is not an outcome one would expect from a nation rich in scientific talent at many universities" while Aldridge and Audretsch claim that the "paucity" of university start-ups post-Bayh-Dole is "startling and disappointing."[230] The dominance of a few patents should not be a surprise. At many firms, a few key products dominate revenue streams. However, maintaining money losing TTOs is another matter.[231]

Efforts to shift research into the economy at large pose three key challenges. First, it is not a major revenue source for universities. Aside from the occasional blockbuster (such as Gatorade™), earning enough licensing revenue to cover operating the TTO and paying for intellectual property is likely the best outcome for many inventions. Second, there are persistent concerns about the impact of pursuing commercialization opportunities on core university missions in research and teaching.[232] "The incorporation of 'extension of knowledge' into a compatible relationship with 'capitalization of knowledge' is a profound normative change in science."[233] While we are skeptical of these concerns, their persistence means they need to be addressed to get faculty buy-in (or, at least, acquiescence) to the commercialization effort. Third, a focus on protecting intellectual property may have a deleterious effect on innovation outside the university.[234] The evidence does

[228] Nelson, *supra* note 196, at 17.

[229] Jensen & Thursby, *supra* note 80, at 243.

[230] T. Taylor Aldridge & David Audretsch, *The Bayh-Dole Act and Scientist Entrepreneurship*, 40 RSCH. POL'Y 1058, 1059 (2011). Litan et al. conclude that it *is* the product of a centralized TTO process where the office is rewarded for revenue rather than the volume of inventions transferred or commercialized. Litan et al., *supra* note 109, at 41. Like any monopoly, they argue, TTOs maximize revenue over output. *Id*. at 43.

[231] Only a small number of universities are major-league recipients of federal grant money, but many schools would like to be, so they ape the behavior of big-time research institutions by putting in place TTOs and other features that are observed. Showing that a school improved federal grant revenue can be helpful for administrators who want to work their way into jobs at more prestigious schools. Rate of return on such expenditures is rarely discussed, as such metrics are rarely used for anything done at universities.

[232] *See, e.g.*, Conceição et al., *supra* note 227, at 621-22; Grigg, *supra* note 79, at 288.

[233] Henry Etzkowitz, *The Norms of Entrepreneurial Science: Cognitive Effects of the New University-Industry Linkages*, 27 RSCH. POL'Y 823, 824 (1998) [hereinafter Etzkowitz, *Norms*].

[234] For example, Bok notes that in a few instances TTOs have impeded sharing of important research tools with other universities by demanding a share in the royalties from inventions resulting from the tools' use

not suggest this is a major problem, but more investigation must be done before the concerns can be addressed.[235]

The institutional context in which university commercialization efforts take place is complex. It is shaped in part by a statute built around an overly simplistic model of the production and translation of knowledge. Its primary effect appears to be the creation of university TTOs, which poses problems (e.g., how will they be paid for?) and focuses on solutions (licensing, patenting, creating new ventures) but does not solve the fundamental puzzle: that the vast majority of research universities are not producing research that takes the important initial step of being patented. We next turn to how this affects universities' operations.[236]

B. Current Practice

The first step in commercialization is the discovery of an idea.[237] The focus of the researcher is likely to be producing a paper, not commercialization.[238] That process begins when the faculty member files a disclosure form with the university's TTO.[239] The form describes the idea and triggers the TTO process. "Faculty decisions to disclose, then, are shaped by the mixture of individual incentives, local organizational procedures, and institutional milieus. The meanings academic researchers attach to IP and their perceptions of the local patent process color decisions to disclose potentially valuable inventions within the

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or by exclusively licensing discoveries too far upstream from applications, and so have "prevented a healthy competition to exploit the patented knowledge." BOK, *supra* note 81, at 141.

[235] Jerry G. Thursby & Sukanya Kemp, *Growth and Productive Efficiency of University Intellectual Property Licensing*, 31 RSCH. POL'Y 109, 122 (2002) (noting that as commercialization efforts increase "the criticisms of those who feel that universities have gone too far in commercialization activities may be increasing in relevance.").

[236] Part of Morriss' position as Dean of the School of Innovation was an analysis of how to improve commercialization efforts at Texas A&M. With colleagues, he visited twenty leading university operations, spoke with various industry leaders, and reviewed the literature to determine best practices. The next section draws on the results of this review and is under-footnoted but Morriss retains original notes.

[237] William H.A. Johnson, *Managing University Technology Development Using Organizational Control Theory*, 40 RSCH. POL'Y 842, 845 (2011).

[238] *Id*. at 846.

[239] Different universities organize this function in different ways. The most common is a centralized office for the entire university, but some have decentralized offices in particular units (e.g., a medical school), some use contractors, and some have separate foundations that handle technology transfer. *See generally* F. Brescia, G. Colombo & P. Landoni, *Organizational Structures of Knowledge Transfer Offices: An Analysis of the World's Top-Ranked Universities*, 41 J. TECH. TRANSFER 132 (2016); U.S. Gen. Acct. Off., GAO/RCED-98-126, Technology Transfer: Administration of the Bayh-Dole Act by Research Universities (1998).

context of a university's history, environment, capacity, and reputation."[240] Patents also reflect the "seizing of opportunities along a novel research trajectory."[241]

The next stage is an evaluation of the idea. In the best case, this involves analysis in three dimensions: intellectual property potential, business potential, and technology potential.[242]

- The IP evaluation focuses on if the idea can be protected by intellectual property (typically a patent). Among the questions asked is: Has the idea been disclosed (through a paper or presentation) in a way that precludes issuance of a patent?
- The business potential assessment involves examining potential demand (Are there customers? How much better is the product than its competition?) and the type of business likely needed to commercialize the idea (Is this something best licensed to an existing firm or developed through a start-up?).[243]
- The technology potential assessment asks if the technology is ready for commercialization. Because much of federal funding focuses on basic research, there is often a problem that the innovation is not mature enough for commercialization.[244]

Then the university decides whether to pursue commercialization. Who makes the decision differs across universities. At some, the central TTO or other entity does, while at others the decision is delegated to the unit where the researcher resides. Generally, decision-making follows the funding of patent applications. To some

[240] Owen-Smith & Powell, *supra* note 197, at 99-100. The reasons why faculty patent vary widely across disciplines. Owen-Smith and Powell quote a TLO director – "[p]hysical scientists patent for freedom of action, life scientists patent for strategic advantage" – as an illustration of their conclusion that "life science inventions have a larger potential to open new markets where gaining value from intellectual property will not be constrained by existing products or patents. In contrast, physical sciences inventions . . . often enter crowded markets where established products and intellectual property hamper organizations' abilities to gain revenue from IP." *Id*. at 105.

[241] Azoulay et al., *supra* note 198, at 619.

[242] Dagmara M. Weckowska, *Learning in University Technology Transfer Offices: Transactions-Focused and Relations-Focused Approaches to Commercialization of Academic Research*, 41-42 TECHNOVATION 62, 63 (2015) (providing a concise description of the analysis).

[243] As we note, most faculty have no expertise in commercialization of research, but self-interest leads to serious disputes between inventors, who want to keep control and want more of the revenue, and school administrators, who have to pay certain costs and want more revenue to come to the school in case of success.

[244] H.R. Tech & Innovation Hearing, *supra* note 14, at 43-44.

extent, this decision is based on cost, although the prestige of getting a patent at some universities or in some departments may spur some demand for non-economically viable patents to be pursued. Some universities emphasize particular disciplines for commercialization; others take a general approach.[245] The initial up-front cost to a university of a provisional patent is generally relatively low ($3,000 is a range often mentioned). Pursuing a full patent usually costs considerably more ($10,000 to $25,000, depending on the area of technology and the complexity of the invention).[246] Universities often seek to recapture these expenses from licensees.[247] There can be a conflict of goals at this stage, with inventors preferring to own and TTOs preferring to license.[248]

Once an idea has been protected, a decision is made whether to seek to license the IP to a firm or to form a spin-off to further develop the idea. One issue is if there is a sponsored research agreement with a funder that might provide a right of first refusal and how the technology fits within the market. It appears that the more an idea needs a Schumpeterian entrepreneur, the more likely the idea is to be licensed to a start-up or existing firm that focuses on the idea. The more the idea produces a small change in an existing technology or process, the more likely it is to be licensed to an existing firm.

Universities vary in the services provided to new ventures that license the results of faculty research. Some universities take equity stakes in new ventures in lieu of license payments, others want royalties from the start, and others have deferred payment "express" license packages that pay lump sums when the venture receives outside funding.[249] Some universities participate in incubators

[245] Joshua B. Powers & Patricia P. McDougall, *University Start-Up Formation and Technology Licensing with Firms that Go Public: A Resource-Based View of Academic Entrepreneurship*, 20 J. Bus. Venturing 291, 306 (2005) [hereinafter Powers & McDougall, *University Start-Up Formation*].

[246] Patent expenses are often recouped from licensees, but this can take time. *See* H.R. Tech & Innovation Hearing, *supra* note 14, at 25 (statement of Catherine Innes, Dir., Off. of Tech. Dev., Univ. of N.C. at Chapel Hill) (discussing the need for universities to carry patent expenses for longer than originally anticipated).

[247] *Id*.

[248] Johnson, *supra* note 237, at 847.

[249] The University of North Carolina pioneered an "express license" program with local law firms, which do not take a fee, for start-ups with a UNC connection and which submit a business plan for university review. This requires a 0.75% value payout in lieu of equity and royalty payments at the first liquidity event. *See* H.R. Tech & Innovation Hearing, *supra* note 14, at 25 (statement of Catherine Innes, Dir., Off. of Tech. Dev., Univ. of N.C. at Chapel Hill); *see also* Grimaldi et al., *supra* note 221, at 1049. Michigan created the "Research Advantage" program that bounds license terms even before an invention is created to cut transaction costs.

that help start-ups develop, some provide gap funding to develop ideas (often without requiring equity or repayment), and some do relatively little. Experienced businesspeople may be brought in as entrepreneurs or executives-in-residence to mentor university researchers who wish to start their own company. Some universities participate in the National Science Foundation's I-Corps program, which puts would-be researcher entrepreneurs through a multi-week start-up boot camp focused on learning the market for an idea. Federal funding through the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs also provides early-stage financial assistance for some university start-ups.[250] Many states provide similar funds to supplement federal programs.[251] In addition, there are informal technology transfers, including coauthoring papers with industry personnel and faculty serving as consultants to outside firms.[252]

Some university efforts for start-ups focus on getting the researcher with an invention up to speed as an entrepreneur. "There is more than one route to the commercialization of university intellectual property (IP) but that, whatever the route, core to its success will be the role played by the creator of the IP, the individual scientist or engineer."[253] This requires considerable effort, and many researchers lack business acumen. The focus of these efforts is on access to funding and business skills.

See H.R. Tech & Innovation Hearing, *supra* note 14, at 56 (statement of Kent Nisbet, Exec. Dir., Univ. of Mich. Tech. Transfer). Maryland operates an "Innovation Initiative" that "mines" five universities' research. *See* H.R. Tech & Innovation Hearing, *Id*. at 40 (statement of Robert Rosenbaum, President & Exec. Dir., Md. Tech. Dev. Corp.).

[250] *See generally* Ronald S. Cooper, *Purpose and Performance of the Small Business Innovation Research (SBIR) Program*, 20 SMALL BUS. ECON. 137 (2003); David B. Audretsch, *Standing on the Shoulders of Midgets: The U.S. Small Business Innovation Research Program (SBIR)*, 20 SMALL BUS. ECON. 129 (2003); Henry Etzkowitz & Loet Leydesdorff, *The Dynamics of Innovation: From National Systems and "Mode 2" to a Triple Helix of University-Industry-Government Relations*, 29 RSCH. POL'Y 109, 110 (2000); Toole & Czarnitzki, *Biomedical Academic Entrepreneurship Through the SBIR Program*, *supra* note 165, at 717 (explaining that investments in early-stage technologies are characterized by high degrees of technical and market uncertainty, which makes other sources of funding difficult); Josh Lerner, *The Government as Venture Capitalist: The Long-Run Impact of the SBIR Program*, 72 J. BUS. 285 (1999); Powers & McDougall, *Policy Orientation*, *supra* note 178, at 1041.

[251] Lauren Lanahan & Maryann P. Feldman, *Multilevel Innovation Policy Mix: A Closer Look at State Policies that Augment the Federal SBIR Program*, 44 RSCH. POL'Y 1387 (2015).

[252] Albert N. Link, Donald S. Siegel & Barry Bozeman, *An Empirical Analysis of the Propensity of Academics to Engage in Informal University Technology Transfer*, 16 INDUS. & CORP. CHANGE 641 (2007).

[253] Mike Wright, Sue Birley & Simon Mosey, *Entrepreneurship and University Technology Transfer*, 29 J. TECH. TRANSFER 235, 235 (2004).

If Schumpeter's description of the role of the entrepreneur is accurate, such efforts are unlikely to be enough. It is not clear if Schumpeter thought that entrepreneurship could be taught or if it derived from some combination of personality traits and experiences.[254] There is some evidence that individual characteristics (which Clarysse, Tartari, and Salter say are "to a large extent genetically imprinted") of potential faculty entrepreneurs play the most significant role in the decision to become an entrepreneur.[255] Similarly, Haye and Pries found that "repeat commercializers" accounted for a disproportionate share of commercialization in their sample.[256] Despite the proliferation of university-based entrepreneurship courses in recent years, it is difficult to know whether the training universities provide is teaching what is needed to be an entrepreneur.

There are proposals to improve the track record of bringing university-developed ideas into the world. Some critics argue that many universities' focus on exclusive licensing rights is an obstacle to successful incorporation of ideas from into products; they contend that universities should prioritize non-exclusive licenses.[257] Others argue that control of commercialization should be shifted away from university administration and given to research faculty.[258] Conflicts between universities and faculty over ownership of ideas threaten to disrupt the core academic mission of universities.[259] Some proposals would fundamentally

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[254] In *Creative Response*, Schumpeter referred to entrepreneurs as a distinct "sociological and psychological" type. Schumpeter, *Creative Response*, *supra* note 32, at 224. Elsewhere he noted "some distinct entrepreneurial ability in making decisions under uncertainty" might exist, suggesting that this led in the direction of Knight's theories. *See* Schumpeter, *Economic Theory and Entrepreneurial History*, *supra* note 32, at 257. Both these comments suggest teaching entrepreneurship would be difficult. However, he also talked about entrepreneurship as "to act outside the pale of routine" and "essentially... doing things that are not generally done in the ordinary course of business routine" and as part of the "wider aspect of leadership." *Id*. at 258, 260.

[255] Clarysse, Tartari & Salter, *supra* note 194, at 1092.

[256] Kate Hoye & Fred Pries, *'Repeat Commercializers,' The 'Habitual Entrepreneurs' of University-Industry Technology Transfer*, 29 TECHNOVATION 682, 687 (2009).

[257] Ian Ayres & Lisa Larrimore Ouellette,*A Market Test for Bayh-Dole Patents*, 102 CORNELL L. REV. 271, 298 (2017); Mark Lemley, *Are Universities Patent Trolls?*, 18 FORDHAM INTELL. PROP. MEDIA & ENT. L.J. 611, 616 (2008).

[258] Kanarfogel, *supra* note 214, at 549 ("As the ones closest to the actual ground of technological and scientific research, faculty members are more intimately aware of the states of the fields in which they work than most anyone else. They will have a sense . . . of what ideas promise expansive or revolutionary further work and which are already close to marketability.").

[259] Grimaldi et al., *supra* note 221, at 1050 ("[M]any TTOs have become increasingly aggressive in claiming their rights to any inventions by researchers affiliated with their university or unilaterally changing

change how universities conduct research and move ideas into the economy. Few are built around a coherent theory of the entrepreneur's role.

III
Entrepreneurship & Red Boxes

We know for-profit firms wish to earn profits from innovations. How innovations emerge and are translated into successes is largely, in economics, still a black box matter. Universities wish for innovations to generate revenue, but they are not-for-profit entities. How entrepreneurial exploitation can happen within such red box organizations is not well understood. If we use Schumpeter's and Kirzner's insights into the role of the entrepreneur, how might we restructure university efforts at moving inventions from the lab to market? This section offers four suggestions. Our argument does not simply suggest universities devote more resources to commercialization.[260] Rather, this is an argument for an approach that built on Schumpeter's and Kirzner's ideas about entrepreneurship and innovation.

A. Focus on the Entrepreneur

Schumpeter argued that the essential function of the entrepreneur is "the doing of new things or the doing of things that are already being done in a new way (innovation)."[261] He distinguished this function from invention, management, risk-bearing, and financing – all necessary functions but ones provided by others (inventors, managers, capitalists, etc.).[262] The entrepreneur adds something and is not, as Schumpeter put it in rebutting a simplistic idea of growth, "a sort of beast of prey who withhold the fruits of technological advance from the community and sabotage progress in their own interest."[263] Kirzner developed the idea of alertness further: "Entrepreneurial alertness means the ability to impose constraints

the formulae for dividing any patent income. This has led not only to researcher discontent and internal administrative investigations, but also litigation initiated by universities against their employees, including prestigious faculty members.").

[260] One commentator on TTO operations concluded by calling for universities to evaluate "their own access to capital, staff adequacy and capabilities of their TTOs, and other intangibles that affect commercialization capabilities" to determine if they "possess the same resources as an MIT or Johns Hopkins" and, if they do not, then to "seek out alternative ways to get their invention out of their own hands and into the hands of those capable of doing so." Krumm, *supra* note 19, at 193.

[261] Schumpeter, *Creative Response*, *supra* note 32, at 223.

[262] *Id*. ("It is one thing to set up a concern embodying a new idea and another thing to head the administration of a going concern, however much the two may shade off into each other.").

[263] Schumpeter, *Economic Theory and Entrepreneurial History*, *supra* note 32, at 265.

on that freedom, so that the entrepreneur's vision of the future may indeed overlap, to some significant extent, with the future that he is attempting to see."[264] This is critical to economic advances that arise from inventions; otherwise firms are only determining "wandering terms of exchange" for existing goods.[265] The costly launching of innovative products requires conscious action by entrepreneurs, be they existing enterprises or new firms created for that purpose. Such expertise divorced from the invention process itself. "Entrepreneurship is... not something to be deliberately introduced into a potential production process: it is, instead, something primordial to the very idea of a potential production process awaiting possible implementation."[266]

Is the entrepreneurial function present in the university process described above? While it may be, it is rarely recognized or explicitly addressed and, if it is addressed, it is done so accidentally. As a result, red boxes underperform their potential to seed the economy with new ideas. Incorporating a Schumpeterian perspective would increase the success rate in moving ideas from research to the economy.

Inventors do not know if an invention, regardless of how highly it is regarded by the inventors, if pushed forward, will have sufficient market value to be deemed a success.[267] As Kirzner explains, this leads us into uncertainty or open-ended ignorance. The possibility of failure or success is not known. It is unlike risk, which is closed-ended ignorance—if you flip a coin, you do not know if it will come up heads or tails, but you know it will be one or the other and you know what the chances are so you can measure the risk.[268] New products

[264] Israel Kirzner, *Uncertainty, Discovery, and Human Action: A Study of the Entrepreneurial Profile in The Misesian System*, in METHOD, PROCESS, AND AUSTRIAN ECONOMICS: ESSAYS IN HONOR OF LUDWIG VON MISES 179 (1982) [hereinafter Kirzner, *Uncertainty, Discovery & Human Action*].

[265] Israel Kirzner, *Mises on Entrepreneurship*, in THE COLLECTED WORKS OF ISRAEL M KIRZNER: LUDWIG VON MISES: THE MAN AND HIS ECONOMICS 154 (Peter Boettke & Frederic Sautet, eds., 2019).

[266] Israel Kirzner, *The Primacy of Entrepreneurial Discovery*, in THE COLLECTED WORKS OF ISRAEL M. KIRZNER: REFLECTION ON ETHICS, FREEDOM, WELFARE ECONOMICS, POLICY, AND THE LEGACY OF AUSTRIAN ECONOMICS 368 (Peter Boettke & Frédéric Sautet, eds., 2018).

[267] That does not mean that the work may not have value—it may help people understand something better that may lead to further productive work. But the work may not have specific value in the market. It is possible that the work may have market value but that no entrepreneur sees the opportunity.

[268] Israel Kirzner, *Discovery, Capitalism, and Distributive Justice*, in DISCOVERY, CAPITALISM, AND DISTRIBUTIVE JUSTICE: THE COLLECTED WORKS OF ISRAEL KIRZNER 38-39 (Peter J. Boettke & Frederic Sautet, eds., 2016) [hereinafter Kirzner, *Discovery, Capitalism & Distributive Justice*]. Open-ended

are launched into an uncertain world of open-ended ignorance. Capitalists risk capital in such ventures. They put their money into a black box to generate the product for the market. University managers are not capitalists, and they should not be risking taxpayer or student tuition money in endeavors unrelated to the educational mission by actually launching products. While worthy inventions arise in red boxes, TTO managers offer inventions to entrepreneurs who may be interested in them. That way, information about the possible opportunities are made known and firms may bid to risk capital and pay for the chance to promote an invention.[269] The economy benefits from the progress generated by such "dynamic competition" from the introduction of new products.[270] In such instances, investors are entrepreneurs—they operate in uncertainty where the outcome cannot be known. Such "entrepreneurial activity expresses pure discovery."[271]

Unfortunately, the university process described above, which results from the Bayh-Dole framework, reflects a view of economic growth inconsistent with Schumpeter's and Kirzner's insights.[272] University TTOs evaluate disclosures from faculty to identify those meriting an investment in intellectual property protection and then determine whether to seek to license the invention to an existing firm or to support the creation of a new firm. The TTO can execute this function well or not, but the paradigm remains primarily a straightforward linear process from

uncertainty is, as Kirzner recognizes, often called Knightian uncertainty for Frank Knight, RISK, UNCERTAINTY AND PROFIT (1921).

[269] This is a real-world process that is not modeled in the black box view of the firm. But real people are making real decisions about real inventions that require real capital. Without that, there can be no discovery of new economic value. Kirzner, *Discovery, Capitalism & Distributive Justice*, *supra* note 268, at 40-41.

[270] *Id*. at 84. Without dynamic change caused by new inventions, firms are engaged in static competition—the same products competing against each other, which is the essence of pure competition as taught in basic economics.

[271] *Id*. at 87.

[272] This the "Smith-Mill-Marshall" theory of economic growth, which Schumpeter critiqued because it implied that "the economy grows like a tree." In this view, while sometimes the economy is "exposed to disturbances by external factors that are not economic, or not strictly so," the growth process itself "proceeds steadily and continuously" and "the individuals, whose acts combine to produce each situation, count individually for no more than do the individual cells of the tree." Joseph A. Schumpeter, *Theoretical Problems of Economic Growth*, in ESSAYS ON ENTREPRENEURS, INNOVATIONS, BUSINESS CYCLES, AND THE EVOLUTION OF CAPITALISM 238 (Richard V. Clemence, ed., 2008) (1947).

idea to disclosure to product.[273] As discussed, this linear progression rarely reflects reality.[274]

Research teams often consist of faculty and, perhaps, some graduate or post-doctoral students.[275] The team experiments, theorizes, and develops results that reach the point at which team members are ready to share them through publications. If the idea appears to a team leader to be viable, they may file a disclosure with the TTO. From a practical point of view, this highlights the importance of the TTO staff regularly interacting with faculty. More conversations about researchers' work will prompt more disclosures. Conceptually, the entrepreneurial content is an accident of whether or not a team member

[273] Frieder Meyer-Krahmer & Ulrich Schmoch, *Science-based technologies: university-industry interactions in four fields*, 27 Rsch. Pol'y 835, 848 (1998) ("Although there is a broad consensus that the linear model of innovation is inadequate, the concept of the 'one-way bridge' from public research to industrial research is still widespread in the discussion on technology transfer."); *see also* Siegel et al., *supra* note 92, at 119 (describing theoretical linear model); *id*. at 138 (presenting non-linear alternative). There is also a literature on the linear model of innovation, from basic to applied research to development and commercialization, derived from Vannevar Bush's conceptualization after World War II. *See* Stokes, *supra* note 2, at 10; Wesley M. Cohen, Richard R. Nelson & John P. Walsh, *Links and Impacts: The Influence of Public Research on Industrial R&D*, 48 Mgt. Sci. 1 (2002). As Cohen, Nelson, and Walsh note, this too has been replaced with a more complex model. *Id*. Etzkowitz and Leydesdorff describe the Triple Helix nonlinear model of innovation, which a future draft will consider in more detail. Etzkowitz & Leydesdorff, *supra* note 250, at 114-115.

[274] Conceição et al., *supra* note 227, at 621-22 (finding need for "an integrated and interactive approach that blends scientific, technological, socio-economic and cultural aspects in rapidly moving environments"); Grigg, *supra* note 79, at 289 (arguing that a cyclic model of innovation better reflects the interaction between "market pull" and "science push"); Lee & Gaertner, *supra* note 169, at 389-90 ("technological innovation does not move sequentially; rather it is an iterative process that must respond to the dynamics of the competitive marketplace. . . . this process is absent in the traditional, industry-based innovation literature."); Frederic Nlevmvo Ndonzoau, Fabrice Pirnay & Bernard Surlemont, *A Stage Model of Academic Spin-Off Creation*, 22 Technovation 281, 282-283 (2002) ("The process [of creating a startup] is neither straightforward nor spontaneous. Instead, it is strewn with numerous obstacles, difficulties, impediments, hindrances, and other sources of resistance.").

[275] Andy Lockett, Mike Wright & Stephen Franklin, *Technology Transfer and Universities' Spin-Out Strategies*, 20 Sm. Bus. Econ. 185, 188 (2003) ("The academic inventor is assumed to be particularly knowledgeable about his/her area of research, which has resulted in the development of the new technology. However, although the academic may be highly knowledgeable about his/her field of research, he/she may not be able to recognize its commercial potential. The inability to recognize such opportunities is not necessarily the result of a lack of information. Rather, the mindset of the academic may mean that they are not necessarily motivated or interested in considering the potential commercial applications of their research."). Graduate students appear to play a critical role in start-ups. *See* Wai Fong Boh, Uzi De-Haan & Robert Strom, *University technology transfer through entrepreneurship: faculty and students in spinoffs*, 41 J. Tech. Transfer 661, 668 (2016).

or someone who learns about the research has something of a Schumpeterian entrepreneurial mindset.[276] In other words, is someone involved with the team thinking about the doing of new things?[277]

Although there is reason to believe (as discussed above) that universities have a comparative advantage in attracting creative people who can generate innovative ideas, there is no particular reason that faculty (or anyone else in a university) would be more likely than people in the general environment to have an entrepreneurial mindset unless universities set out to find such people. What we know about entrepreneurs in university start-ups is that we do not know much.[278] Roberts and Peters concluded from their survey of MIT faculty that although a large percentage of faculty at MIT were likely to generate ideas with commercial value, only a "smaller fraction. . . can be expected to do anything toward exploiting these ideas; even fewer to undertake strong commercially oriented actions."[279] Smilor, Gibson and Dietrich's study of the motivation of faculty entrepreneurs at the University of Texas at Austin found self-reported motivations for forming a start-up to include "recognition of a market opportunity, desire to try something new, desire to put theory into practice, the prospect of business contracts, the desire to start a company, and the desire to have fun with an entrepreneurial venture."[280] Another survey found that "engagement with industry may be fueled by an individual's desire to compete effectively in the academic profession."[281] None of this is particularly helpful in identifying entrepreneurial faculty.

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[276] Wright, Birley & Mosey, *supra* note 253, at 241 ("We know little about the extent to which habitual entrepreneurs exist in universities. To the extent that these individuals do exist, there may also be implications here for the development of university processes regarding technology transfer.").

[277] People coming up with new ideas in research are, by definition, thinking of "doing of new things" or doing things "in a new way" but they may not be framing those ideas in commercial terms.

[278] Wright, Birley & Mosey, *supra* note 253, at 240 ("There remains little evidence on the nature of entrepreneurs and their behavior in university technology transfer.").

[279] Roberts & Peters, *supra* note 94, at 122. Rahm distinguished between "spanning" and "university-bound" faculty members in categorizing interactions with firms. Rahm, *supra* note 96, at 274-75. The former was more likely to patent than the latter, among other things. *Id.*

[280] Raymond W. Smilor, David V. Gibson & Glenn B. Dietrich, *University Spin-out Companies: Technology Start-ups from UT-Austin*, 5 J. BUS. VENTURING 63, 69 (1990).

[281] Tartari et al., *supra* note 110, at 1201. Discussions between TTOs and faculty inventors about sharing costs of exploitation, so the inventors have a deeper stake in success is part of complex negotiations and contract structures.

One reason for the difficulty in finding entrepreneurs on campuses is that they aren't there. Many people with an entrepreneurial mindset are likely to have chosen career paths that enabled them to have the chance to become entrepreneurs without bearing the costs to acquire a Ph.D., get a job as a faculty member, and then develop their ideas.[282] In many respects the stereotypical entrepreneurs are those who leave universities (sometimes without degrees) when they have entrepreneurial ideas they want to pursue (e.g., Sergey Brin, Bill Gates, and Larry Page).

This does not mean entrepreneurship is absent on campus. Etzkowitz argues that academic scientists are willing to mingle research and product development, with a "transmutation of ambivalence…into consonance" and the integration of entrepreneurship and basic research into "a complementary relationship."[283] If so, universities may have interest in encouraging entrepreneurship among research faculty. There is evidence that universities where faculty have greater ownership of their intellectual property produce more spinoff companies.[284]

Taking a more Schumpeterian-Kirznerian approach to commercialization requires focusing attention on the entrepreneurial potential a team might develop to build a business around the invention. As Schumpeter notes, "It is in most cases only one man or a few men who see the new possibility and are able to cope with the resistances and difficulties which action always meets with outside of the ruts of established practice."[285] One implication would be that a focus for ideas being licensed to new ventures should be on identifying team members who have entrepreneurial skills rather than on training team members to become entrepreneurs.[286] (Because universities are not organized around other necessary functions for a business, matching start-ups with managerial and financing skills

[282] See Bok, *supra* note 81, at 62 ("the values that have traditionally inspired academic scientists have generally been strong enough to withstand the desire to grow rich."). Agarwal and Ohyama develop a sorting model for science careers. Rajshree Agarwal & Atsushi Ohyama, *Industry or Academia, Basic or Applied? Career Choices and Earnings Trajectories of Scientists*, 59 Mgt. Sci. 950 (2013).

[283] Etzkowitz, *Norms*, *supra* note 233, at 827.

[284] Martin Kenney & Donald Patton, *Does Inventor Ownership Encourage University Research-derived Entrepreneurship? A Six University Comparison*, 40 Rsch. Pol'y 1100, 1109 (2011).

[285] Schumpeter, *Creative Response*, *supra* note 32, at 224.

[286] There is some evidence that university-connected start-ups have under-developed management teams. Michael D. Ensley & Keith M. Hmieleski, *A Comparative Study of New Venture Top Management Team Composition, Dynamics and Performance between University-based and Independent Start-ups*, 34 Rsch. Pol'y 1091, 1102 (2005).

is also necessary.) For inventions being licensed, putting a priority on licensing to firms that demonstrate entrepreneurial skills would add an appropriate dimension to the criteria for evaluating potential licensees.

There are efforts to do some of this. The NSF initiated the "I-Corps" program to put faculty and graduate students who have NSF grants through start-up training focused on gaining knowledge of the potential market for inventions through interviews with potential customers. A common comment about I-Corps is that part of its value is that it disabuses some faculty inventors who think they are entrepreneurs of that notion by showing them what is involved, persuading them to focus on their strength in invention. Part of its value is in encouraging university-connected start-ups to find outside entrepreneurs to join them. Many universities and communities provide incubators and accelerators to support start-up businesses with physical space, equipment, support services, and mentoring.[287] Expanding the number of universities participating in I-Corps and with incubators would likely improve universities' overall success at commercialization.

However, the entrepreneurial function for ideas coming out of university research requires more than training programs for faculty in aspects of being an entrepreneur. Some faculty have ideas they would like to see marketed but are not personally interested in being entrepreneurs or, even if they are, lack the requisite skills.[288] Then, matching ideas to potential entrepreneurs from the outside is necessary. Entrepreneurial abilities are scarce resources generally, so increasing their availability is critical to the transformation of ideas into impact in the broader community. Unfortunately, one of Schumpeter's fundamental points was that competent entrepreneurs are harder to come by than money for entrepreneurs to use.[289]

Kirzner emphasizes that markets are filled with uncertainty. Were they not, things would be simple: "Without uncertainty... decision making would no longer call for any imaginative, creative determination of what the circumstances really are. Decision making would call merely for competent calculation. Its results could,

[287] Frank T. Rothaermel & Marie Thursby, *Incubator firm failure or graduation? The role of university linkages*, 34 RSCH. POL'Y 1076 (2005) (describing role of incubators).

[288] Etzkowitz, *Norms*, *supra* note 233, at 831.

[289] Schumpeter, *Creative Response*, *supra* note 32, at 223, n. 5 (it became "increasingly easier to obtain other people's money by methods other than the partnership" over 19th century).

in general, be predicted without doubt. Human judgment would have no scope."[290] Universities are not stocked with entrepreneurs, so managers emerging from red boxes likely have worse information about market opportunities than do black box managers. Red box managers, such as TTO directors, lack the experience of firms that, despite making errors, are more likely to come closer to what may be received in the market than are a team of inventors working within a university who have less information about what may be marketable. Red box managers generally know less about what is required to launch products and do not bear the costs of launching inventions. It is not a simple process. Part of the solution is to focus on university culture, which we turn to next.

B. Building an Entrepreneurial Culture

For entrepreneurs, there is no equivalent to Smith's invisible hand. Indeed, the reason efforts are inside a red (or black) box is because conscious coordination is needed. The frequency of the "creative response" that entrepreneurs have, which is key to being entrepreneurial, is connected "(a) with quality of the personnel available in a society, (b) with relative quality of personnel, that is, with quality available to a particular field of activity relative to quality available at the same time, to others, and (c) with individual decisions, actions, and patterns of behavior."[291] The quality available is something universities can do little about, but they can take steps to enhance the second and third contributing factors. Recruiting those who have a "creative response" to improve the pool of potential entrepreneurs within the university is possible.[292] Research into entrepreneurship may help understand how to identify potential entrepreneurs. Advertising a desire to have them and provision of programs can bring students and faculty with entrepreneurial talents to a university. Entrepreneur-in-Residence programs provide visits by successful entrepreneurs. Other programs, including project-based classes, mentoring programs, accelerators and incubators, business plan competitions, and business training may help.[293]

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[290] Kirzner, *Uncertainty, Discovery & Human Action*, *supra* note 264, at 166.

[291] Schumpeter, *Creative Response*, *supra* note 32, at 222.

[292] Clarysse, Tartari & Salter, *supra* note 194, at 1092 ("The university's potential for commercializing its research results through entrepreneurial ventures is liable to depend on its ability to attract and retain academics with high levels of entrepreneurial capacity."). Hiring people who do not "look like" traditional academics is a major challenge at many universities.

[293] Boh, De-Haan & Strom, *supra* note 275, at 665.

Doing well at commercialization—in a bit of a chicken-and-egg conundrum—can help.[294] For example, one particularly successful TTO administrator said that faculty candidates often ask to meet with the TTO staff to learn whether or not that university is successful at commercializing faculty inventions.[295] Being known in the academic community as a university that provides resources to help faculty entrepreneurs and values their efforts will increase the "relative quality of personnel." Etzkowitz points to the importance of the creation of a "penumbra" of firms around the university.[296] Patenting and licensing may be common only in a narrow swath of universities, making it unlikely those activities change the broader culture.[297]

Less attention has been paid to building student entrepreneurship, although Grimaldi *et al.* make a case for giving it attention.[298] Bergmann *et al.* show the importance of climate and culture for students, particularly those not predisposed to be interested in entrepreneurship.[299] The University of Utah's Lassonde Studio is a leading example of a student-focused entrepreneurship program. Incorporating a living-learning community of 400 students with broader programs for the general student body, the program brings in students who have an entrepreneurial mindset and fosters its development.

A common theme in campus discussions of commercialization is whether the campus culture includes entrepreneurial success as something to be valued.[300] This may be critical. Economic historian Deidre McCloskey argues that what set

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[294] Owen-Smith & Powell, *supra* note 197, at 109 ("Differences in faculty perceptions of patent processes and infrastructures across the campuses" help explain inter-university differences in disclosure rates).

[295] H.R. Tech & Innovation Hearing, *supra* note 14, at 53 (statement of Kent Nisbet, Exec. Dir., Univ. of Mich. Tech. Transfer) (faculty recruits at Michigan looking at TTC capabilities); Owen-Smith & Powell, *supra* note 197, at 111 ("A strong culture of patenting attracts faculty interested in pursuing commercial endeavors and socializes new university members into that pursuit.").

[296] Etzkowitz, *Norms*, *supra* note 233, at 829.

[297] MOWERY ET AL., *supra* note 85, at 3.

[298] Grimaldi et al., *supra* note 221, at 1047.

[299] Heiko Bergmann, Mario Geissler, Christian Hundt & Barbara Grave, *The Climate for Entrepreneurship at Higher Education Institutions*, 47 RSCH. POL'Y 700, 701 (2018).

[300] Louis, Blumenthal, Gluck & Soto, *supra* note 194, at 111 (discussing importance of local culture); Owen-Smith & Powell, *supra* note 197, at 111 ("The catch-all phrase 'entrepreneurial culture' is central in informants' explanations of [their university's] commercial success."); *see also* Lockett, Wright & Franklin, *supra* note 275, at 191 ("This is an interesting result that suggests that universities, although keen to transfer technology to the private sector in the case of V10 institutions, do not want the academic to pursue a role in the management of the spin-out.").

off the industrial revolution in Britain and Holland was not a particular confluence of capital, inventions, or markets in those countries. Those factors had been present in other places. What distinguished Britain and Holland were cultural features that were "stumbled upon." There was "a new dignity for the bourgeoisie in its dealings and a new liberty for the bourgeoisie to innovate in economic affairs. Both were necessary for the modern world. The two, when linked, appear even to have been sufficient, if you supply a few routine background conditions enjoyed already in many places, as for example somewhat large cities and extensive trade and reasonable security of property and cheap if slow riverine or coastal transport in a biggish country."[301]

Translating McCloskey's argument to universities, their culture must provide recognition for entrepreneurship by faculty, staff, and students, as well as for more conventional measures of academic success (publications, prizes, grades, etc.) to convey its stature. Owen-Scott and Powell found that an "entrepreneurial culture" was a key differentiator between the two universities they studied and concluded that such culture "is central to informants' explanations" of the more successful university's efforts: "A strong culture of patenting attracts faculty interested in pursuing commercial endeavors and socializes new university members into that pursuit."[302] As our data shows, such a culture exists at only a small fraction of U.S. universities. Similarly, Rasmussen, Mosey, and Wright found departmental level effects on spinoff success that suggest the importance of culture: "Small differences in the local department environment relating to the access

[301] Deirdre N. McCloskey, Bourgeois Dignity: Why Economics Can't Explain the Modern World 393-95 (2010).

[302] Owen-Smith & Powell, *supra* note 197, at 111; *see also* Grigg, *supra* note 79, at 296 (noting "entrepreneurs and entrepreneurship is often viewed with skepticism or even open hostility" within academic culture); Rory P. O'Shea, Thomas J. Allen, Arnaud Chevalier & Frank Roche, *Entrepreneurial Orientation, Technology Transfer and Spinoff Performance of U.S. Universities*, 34 Rsch. Pol'y 994, 1006 (2005) ("public policy and university heads would be advised to intensify their activities to implement educational, research and resource programs to enable a culture of academic entrepreneurship to emerge within universities."). Interestingly, Mowery, Sampat, and Ziedonis concluded that 'learning to patent' by universities was most likely the result of a "diffuse learning process" rather than any change in research culture. David C. Mowery, Bhaven N. Sampat & Arvidis A. Ziedonis, *Learning to Patent: Institutional Experience, Learning, and the Characteristics of U.S. University Patents After the Bayh-Dole Act, 1981-1992*, 48 Mgt. Sci. 73, 87-88 (2002). Even more intriguingly, Marx and Hsu speculate that faculty more inclined to commercialize their research select into "prominent institutions or resource-rich geographies." Matt Marx & David H. Hsu, *Revisiting the Entrepreneurial Commercialization of Academic Science: Evidence from 'Twin' Discoveries*, Nat'l Bureau of Econ. Rsch., Working Paper No. 28203, 2020.

to commercial partners, legitimacy of venturing to the department management and availability of venturing and commercial experience had a disproportionate effect upon subsequent venture development."[303] Examining more than 6,000 life scientists, Ding and Choi found that differences in social networks and institutional support affected the likelihood of creating a start-up or joining a scientific advisory board.[304]

It is not just within the university that there needs to be an emphasis on the entrepreneurial climate. Friedman and Silberman found that the local entrepreneurial climate (as measured by the Milken Foundation Tech-Pole Index) had a statistically significant positive impact on TTO outputs.[305] This is consistent with Florida's insights on the role of a creative community. Powers and McDougall identify being located in an area containing greater venture capital resources with increasing start-ups.[306] Another illustration is in Kenney and Goe's comparative study of Stanford and Berkeley electrical engineering and computer science departments. They found that Stanford faculty believed the university's most important motivation for supporting entrepreneurship by faculty was to increase university prestige while Berkeley faculty ranked that sixth, and believed financial rewards were the most important university motivation.[307] Analyzing faculty relationships with businesses in those departments, Kenney and Goe found that more Stanford faculty had such affiliations; those produced more affiliations, reinforcing the culture.[308] They concluded that "the institutional history, culture,

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[303] Einar Rasmussen, Simon Mosey & Mike Wright, *The Influence of University Departments on the Evolution of Entrepreneurial Competencies in Spin-off Ventures*, 43 RSCH. POL'Y 92, 105 (2014); Tartari et al., *supra* note 110, at 1200 (finding evidence of peer influence within departments).

[304] Waverly Ding & Emily Choi, *Divergent Paths to Commercial Science: A Comparison of Scientists' Founding and Advising Activities*, 40 RSCH. POL'Y 69, 79 (2011).

[305] Friedman & Silberman, *supra* note 226, at 29.

[306] Powers & McDougall, *University Start-up Formation*, *supra* note 245, at 307.

[307] Martin Kenney & W. Richard Goe, *The Role of Social Embeddedness in Professorial Entrepreneurship: A Comparison of Electrical Engineering and Computer Science at UC Berkeley and Stanford*, 33 RSCH. POL'Y 691, 701 (2004).

[308] *Id*. at 704. Murray makes a powerful argument that the social capital faculty inventors bring to firms is also a critical ingredient.

> Firstly academic inventors contribute social capital, in addition to human capital, that can be translated by firms into embeddedness within scientific networks. Secondly, scientific careers play a critical role in establishing social capital and thus mediate a firm's embeddedness within the scientific community. Taken together, these arguments suggest that scientific careers are a

and regulations of the broader university in which a faculty member is embedded influence professorial entrepreneurship and corporate involvement."[309] Creating that is not easy. As former Harvard President Derek Bok notes, "to commercialize a university is to engage in practices widely regarded in the academy as suspect, if not downright disreputable."[310] Some business people's experience leaves them unconvinced that university culture is amenable to entrepreneurial behavior.[311]

A university must also accomplish the second part of McCloskey's formula (which is also Ridley's key insight), allowing the university community the liberty to "innovate in economic affairs," at the least by not imposing too many restrictions. Bayh-Dole took one step toward creating this freedom by loosening some restrictions on entrepreneurial activity involving the results of federally funded research. Universities must also ensure their internal procedures do not squelch such activities.[312]

Universities can build cultures that value entrepreneurship by celebrating it in connection with commercialization.[313] Litan, Mitchell, and Reedy argue that "a university culture that is accepting of entrepreneurial activities is best built

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> key factor shaping science-based firms because they mediate the local and cosmopolitan social capital through which entrepreneurial firms become embedded in the scientific community.

Fiona Murray, *The Role of Academic Inventors in Entrepreneurial Firms: Sharing the Laboratory Life*, 33 Rsch. Pol'y 643, 644 (2004) (A future draft will include more discussion of her analysis.).

309 Kenney & Goe, *supra* note 307, at 704.

310 Bok, *supra* note 81, at 18.

311 H.R. Tech & Innovation Hearing, *supra* note 14, at 39 (statement of Robert Rosenbaum, President & Exec. Dir., Md. Tech. Dev. Corp.) ("I think it is fair to say that universities have a very distinct culture in and of themselves, and the researchers within those universities have a particular headset in and of themselves. Primarily speaking and historically speaking—although it is changing—researchers within universities are very risk-averse.") This may also help explain the otherwise puzzling finding by Markman et al. that more experienced TTOs were negatively correlated with faculty disclosures, which they suggested was driven by that more traditional TTO approaches were less creative in structuring deals and so inducing disclosures. Gideon Markman et al., *Entrepreneurship from the Ivory Tower: Do Incentive Systems Matter?*, 29 J. Tech. Transfer 353, 360 (2004). Powers and McDougall found that more established TTOs produced more start-ups, which they suggested could be due to greater development of the competencies necessary to facilitate the process. *See* Powers & McDougall, *University Start-up Formation*, *supra* note 245, at 306.

312 Discouraging entrepreneurial activity may be inadvertent. While universities may want such activity, internal regulatory constraints may set up so many costly hoops researchers must jump through that few will try and experienced faculty will know to shy away from such institutions. Attempts at universities to "engineer entrepreneurship" often fail. *See* Lee & Gaertner, *supra* note 169, at 129.

313 Gideon D. Markman et al., *Entrepreneurship and University-Based Technology Transfer*, 20 J. Bus. Venturing 241, 253-254 (2005) [hereinafter Markman et al., *Entrepreneurship*].

from the ground up by researchers who promote and connect other colleagues both inside and outside of academe."[314] Schools can recognize and reward those who demonstrate entrepreneurial success, in the same way they reward success in publication or teaching. Entrepreneurship can be formally recognized as contributing to tenure decisions[315] Bringing alumni and community entrepreneurs to campus can help build entrepreneurial culture by recognizing these individuals as worthy participants in the university community and being mentors for potential faculty, staff, and student entrepreneurs.

Boh, De-Haan, and Strom suggest that universities should "leverage all potential university resources for technology transfer" through courses and centers to send a strong message.[316] One possibility is that greater knowledge production by university researchers that leads to publication in papers translates into greater local commercial research. Hicks, et al. found a strong relationship between the location of paper authors and patentees. Scientific knowledge is easy to get from conferences and articles, so distance between the producer and users should not have much impact. Nonetheless, they found a strong relationship.[317]

Changing a university's culture is easier said than done, of course. However, finding ways to build an entrepreneurial culture on campus would be a critical part of a Schumpetarian-Kirznerian approach.

C. Reshaping the Pipeline

A well-functioning TTO is a crucial element of an entrepreneurial campus culture. Researchers disclosing ideas must feel valued and receive the service equivalent of a visit to Apple's Genius Bar, a Disney resort, or a Four Seasons hotel.[318] Rapid responses, transparent processes, and clear feedback are parts of such experience. Wu, Welch and Huang recommend that TTOs focus on identifying

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[314] Litan et al., *supra* note 109, at 48.

[315] Thursby & Kemp, *supra* note 235, at 122 (noting greater specialization in basic research may explain lower commercialization 'efficiency' at higher prestige universities).

[316] Boh, De-Haan & Strom, *supra* note 275, at 667.

[317] Diana Hicks, Tony Breitzman, Dominic Olivastro & Kimberly Hamilton, *The Changing Composition of Innovative Activity in the US – A Portrait Based on Patent Analysis*, 30 RSCH. POL'Y 681, 690-691 (2000).

[318] Owen-Smith & Powell, *supra* note 197, at 112 ("inconvenient or frustrating experiences with TTOs may be enough to convince ambivalent inventors that the benefits of IP protection do not outweigh the costs.").

faculty likely to succeed at commercialization.[319] Complicating this is that roles change on campuses.[320] UK research suggests that TTO business development capabilities are important in the success of spinoffs.[321] Not surprisingly, there are significant learning components to TTOs; experience helps performance.[322] The TTO needs to be treated as more than a revenue creation tool because they generally are not revenue generators (as noted earlier), and treating them as such sends the wrong message to faculty considering filing disclosures. One computer science professor complained in an interview that his university "saw inventions as a way to augment the shrinking university budget" and so the tech transfer office was "overly aggressive in trying to make money," forgetting that for him "money wasn't the primary motivation" but that the goal was to get his ideas "into real-world situations."[323]

Developing relationships between TTO staff and researchers is critical. As Owen-Smith and Powell note, "Most TTOs lack the resources and competencies necessary to search a wide range of laboratories and research groups for commercially viable technologies. Thus, institutional success depends in part on faculty perceptions of the benefits of patenting, the quality of the TTO, and the institution as a collective enterprise."[324] Relationships depend on delivering the level of services that inspire confidence and trust.[325]

A broader role for the TTO can pay dividends. Etzkowitz points to the importance of improving information about the technologies produced at the

[319] Yonghon Wu, Eric W. Welch & Wan-Lin Huang, *Commercialization of University Inventions: Individual and Institutional Factors Affecting Licensing of University Patents*, 36-37 Technovation 12, 24 (2015).

[320] Gideon D. Markman et al., *Innovation Speed: Transferring University Technology to Market*, 34 Rsch. Pol'y 1058, 1062 (2005) [hereinafter Markman et al., *Innovation Speed*].

[321] Andy Lockett & Mike Wright, *Resources, Capabilities, Risk Capital and the Creation of University Spin-out Companies*, 34 Rsch. Pol'y 1043, 1054 (2005).

[322] Gerard George,*Learning to Be Capable: Patenting and Licensing at the Wisconsin Alumni Research Foundation*, 14 Indus. & Corp. Change 119, 141 (2005).

[323] Ed Silverman, *The Trouble with Tech Transfer: Fighting Tech Transfer—and Winning*, 21 Scientist 40, 43 (2007).

[324] Owen-Smith & Powell, *supra* note 197, at 99.

[325] Michael D. Santoro & Shanthi Gopalakrishnan, *Relationship Dynamics between University Research Centers and Industrial Firms: Their Impact on Technology Transfer Activities*, 26 J. Tech. Transfer 163, 168-69 (2001) (discussing the importance of trust in collaborations between industry and university).

university that helps firms reduce uncertainty.[326] Haeussler, Harhoff, and Mueller find that information generated during the patent process has value for venture capitalists independent of the patent itself.[327] Agarwal and Shah point out the importance of micro-level policies to aid start-ups, where providing "access to complementary assets and resources for fledgling academic- and user-founded firms in early stage industries might encourage more rapid commercial introduction of novel innovations."[328] Mowery and Ziedonis find greater "localization" of knowledge spillovers from universities via licenses than through citations of academic work, which they suggest may be due to greater "tacitness" of licensed knowledge demanding closeness for access to the scientist.[329]

In a similar vein, Jain and George refer to TTOs as "uniquely suited to play a significant and active role in building legitimacy for new technologies emerging from university laboratories," while the technology is "still wrapped in a fog of uncertainty that is technical, commercial, social and/or ethical in nature."[330] Examining a study of WARF's role in the human stem cell technology at Wisconsin, they conclude "the activities of a TTO can extend beyond traditional patenting and licensing to include building legitimacy for nascent technologies."[331] Jain and George argue that WARF played the roles of protecting ("insulating the nascent technology from the extant institutional environment in situations where it is hostile to the innovation"), propagating ("dissemination of a coherent group of understandings and beliefs related to the technology" and not just diffusion), and influencing ("coalition building, lobbying, and compromise tactics").[332] TTOs' efforts at these roles "are broadly applicable to other actors considering building

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[326] Etzkowitz, *supra* note 20, at 118.

[327] Carolin Haeussler, Dietmar Harhoff & Elisabeth Mueller, *How Patenting Informs VC Investors – The Case of Biotechnology*, 43 RSCH. POL'Y 1286, 1296 (2014).

[328] Rajshree Agarwal & Sonali K. Shah, *Knowledge Sources of Entrepreneurship: Firm Formation by Academic, User, and Employee Indicators*, 43 RSCH. POL'Y 1109, 1129 (2014).

[329] David C. Mowery & Arvidis A. Ziedonis, *Markets versus Spillovers in Outflows of University Research*, 44 RSCH. POL'Y 50, 59-60 (2015).

[330] Sanjay Jain & Gerard George, *Technology Transfer Offices as Institutional Entrepreneurs: The Case of Wisconsin Alumni Research Foundation and Human Embryonic Stem Cells*, 16 INDUS. & CORP. CHANGE 535, 538 (2007).

[331] *Id*. at 555. In the stem cell case, they note "In its role as an institutional entrepreneur, WARF has been involved in implementing a host of political and socio-cognitive strategies that included lobbying, negotiating, litigating, self-regulating and educating other actors." *Id*.

[332] *Id*. at 557-58.

legitimacy for a nascent technology."[333] The unusually successful WARF differs from most TTOs in that it has "skin in the game" in commercialization.

Beyond competency of a TTO, the implicit linear pipeline of disclosure-patent-license underlying much of current commercialization policy needs to be replaced with a broader vision of academic culture. It is not enough to get a researcher to disclose an idea to the TTO; the idea must be market feasible to be commercialized. This often requires pre-patent development funding to enable a promising idea to reach the stage at which viability can be assessed. As one commentator notes, "the single most common feedback we get from potential licensees is that the technology is too early. So proof-of-principle, proof-of-concept funding is the gating factor to getting more technology to a go-or-no-go decision point."[334] A survey of TTOs finds that universities with higher rankings license a higher proportion of disclosures in the proof-of-concept stage,[335] suggesting that there may be some halo effect to overall reputation. (They may also have better TTOs.) TTOs can play a key role in designing contracts that solve the thorny incentive problems inherent in early-stage inventions. Dechaneaux, Thursby, and Thursby conclude from their survey that proper contract design plays a "critical role" in addressing incentive issues.[336] Universities can also develop mechanisms for involving entrepreneurs in this process, both smoothing the way for faculty to share the critical tacit knowledge they possess and facilitating investment in the often-costly development process.

When the speed of innovation – the time from discovery to commercialization – is critical, universities need faster processes internally. Inventors play a crucial role in speeding up or slowing down particular inventions.[337] Thursby and Thursby note that research shows that "faculty are often involved in the license process well

[333] *Id*. at 562.

[334] H.R. Tech. & Innovation Hearing, *supra* note 14, at 60 (statement of Todd T. Sherer, President, Ass'n of Univ. Tech. Managers).

[335] Jensen et al., *supra* note 80, at 1273; *see also* Wesley David Sine, Scott Shane & Dante Di Gregorio, *The Halo Effect and Technology Licensing: The Influence of Institutional Prestige on the Licensing of University Inventions*, 49 MGT. SCI. 478, 491 (2003) (university prestige increases licensing rate).

[336] Emmanuel Dechenaux, *Inventor moral hazard in university licensing: The role of contracts*, 40 RSCH. POL'Y 94, 102 (2011).

[337] Markman et al., *Entrepreneurship*, *supra* note 313, at 1073.

beyond disclosure."[338] Jensen and Thursby conclude that active participation by the faculty is essential for commercialization.[339]

A broader task for TTOs is translating university research into real world impact. A narrow focus on commercialization as the primary path may miss important opportunities. Litan, Mitchell, and Reedy lament: "[r]ather than implementing broad innovation/commercialization strategies that recognize different and appropriate pathways of commercialization, as well as multiple programs and initiatives to support each path, many have channeled their innovation dissemination activities through a centralized technology transfer office (TTO)." Too often, this results in TTOs becoming "bottlenecks rather than facilitators of innovation dissemination."[340]

D. Supporting Spinoffs

Entrepreneurship is needed for firms to emerge from universities. Spinoffs require particular support. Indeed, "[a]cademic spinoffs, given their technology basis, combine both the traditional problems associated with the start-up of a new business and the difficulties associated with the development of new technologies."[341] They are, of course, capital and credit rationed.[342] Lerner points out that many candidates for start-ups are "characterized by uncertainty and informational gaps, which make it difficult for the investors to evaluate business plans or to oversee the entrepreneurs once the investments are made."[343] He argues that TTOs can play an important role in solving these problems in two dimensions: "reducing the uncertainty of academic entrepreneurs about the spin-out process and easing outside investors' and strategic partners' doubts about the new venture."[344] However Clarysse, Tartari, and Salter point out that, given that it is a desire to be an entrepreneur that drives faculty behavior, "the creation and efforts of

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[338] Jerry G. Thursby & Marie C. Thursby, *Are Faculty Critical? Their Role in University-Industry Licensing*, 22 CONTEMP. ECON. POL'Y 162, 168 (2004).
[339] Jensen & Thursby, *supra* note 80, at 255.
[340] Litan et al., *supra* note 109, at 32.
[341] Ricardo Fini, Rosa Grimaldi, Simone Santoni & Maurizio Solernersalterbrero, *Complements or Substitutes? The Role of Universities and Local Context in Supporting the Creation of Academic Spin-offs*, 40 RSCH. POL'Y 1113, 1114 (2011).
[342] *Id*. at 1114.
[343] Lerner, *supra* note 250, at 50.
[344] *Id*. at 53.

TTOs is of modest or little use in itself unless such a creation is backed up by changes in the hiring and promotion practices of the university itself."[345] Creating a start-up may or may not be the most appropriate means of commercializing some university research.[346] Start-ups are not a priority for all TTOs or university administrations.[347] They have benefits for universities, but also have costs.[348]

> Communities surrounding universities want start-ups as an economic development tool.
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> The key argument is that communities surrounding universities must have the capabilities to absorb and exploit the science and knowledge that universities generate. Even if new knowledge is generated in many places, it is only those regions that can absorb and apply ideas that are able to turn it into economic wealth. As a consequence, universities are a necessary but not sufficient condition for regional economic development.[349]

Students can also play this role.[350]

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345 Clarysse, Tartari & Salter, *supra* note 194, at 1092.

346 Brouwer, *supra* note 5, at 268 ("participating in startups constitutes the ideal technology transfer model for universities because it allows them to get the most from inventions, whose revenues are shrouded in uncertainty."). *But see* Grigg, *supra* note 79, at 294 (noting need for further development of university-derived technologies hinders use of start-ups). If a TTO invests in a failure, the loss is easy to identify and criticize. There is little criticism of deadwood faculty who deliver little value or staff members who do next to nothing, but specific expenditures on a venture that flops presents an opportunity to criticize wasteful efforts to cater to the market.

347 Siegel et al., *supra* note 92, at 130.

348 When a faculty-created invention is commercialized, the creator sometimes leaves academia. A study of MIT start-ups found that there was a significant "brain drain" from the university from this, as the faculty who left were more productive than their replacements. Andrew A. Toole & Dirk Czarniki, *Commercializing Science: Is there a University "Brain Drain" from Academic Entrepreneurship*, 56 MGT. SCI. 1599, 1599 (2010).

349 Fini, Grimaldi, Santoni & Sobrero, *supra* note 341, at 1116.

350 A study of Swedish start-ups between 1994 and 2001 found that 528 came directly from universities but 8,663 came from businesses where university students had taken initial jobs and then later spun-out companies, suggesting universities' educational role is also a powerful source of new ventures. Similarly, U.S. data suggests the gross flow of start-ups from undergraduates with science and engineering degrees is considerably larger than the flow from faculty. Thomas Astebro, Navid Bazzazian & Serguey Braguinsky, *Startups by Recent University Graduates and their Faculty: Implications for University Entrepreneurship Policy*, 41 RSCH. POL'Y 663 (2012).

Spinning off a start-up may not be the right strategy. Evidence suggests this is often the case when the technology needs further development before it is ready for the market, as with many medical devices based on ideas from university researchers.[351] As a result, "many [university] inventions are so embryonic that they might remain in the lab without license agreements designed to induce collaboration between inventors and licensees."[352] This has consequences for license terms, which must be designed to induce collaboration.[353]

Not all technologies are equally likely to result in start-ups. University spin offs commercialize more innovative technologies than industry incumbents' spin offs.[354] This may be the result of an earlier stage of university-related spin off technology. There is evidence that start-ups with radical technologies and strong intellectual property in fragmented industries are more likely to survive.[355] As universities became more experienced with start-ups, they became more comfortable taking equity stakes rather than upfront license fees, which raised additional challenges for TTOs in structuring deals and monitoring

[351] Fontes suggested that "spin-offs tend to emerge as a response to system gaps regarding the exploitation of academic research. These gaps are related both to the nature of the knowledge, which may make its direct exploitation by existing companies less likely, thus calling for some previous transformation or translation conducted by other actors, familiar with that knowledge; and to the nature of the organizational setting where knowledge production takes place, namely the difficulties in conciliating in the same organizational context activities that have fundamentally different objectives and require different governance structures." Margarida Fontes, *The Process of Transformation of Scientific and Technological Knowledge into Economic Value Conducted by Biotechnology Spin-offs*, 25 Technovation 339, 341 (2005).

[352] Jensen & Thursby, *supra* note 80, at 241. At the same time, the uncertainties associated with embryonic technologies increase the risk of choosing the wrong licensee, suggesting flexibility in adapting as learning occurs is important. *See* Jeannette Colyvas et al., *How Do University Innovations Get into Practice?*, 48 Mgt. Sci. 61, 66 (2002).

[353] *Id*. at 255.

[354] Henry Chesbrough, *The Governance and Performance of Xerox' Technology Spin-off Companies*, 32 Rsch. Pol'y 403, 403 (2003); Erwin Danneels, *Disruptive Technology Reconsidered: A Critic and Research Agenda*, 21 J. Prod. Innovation Mgt. 246, 246-258 (2004).

[355] Atul Nerkar & Scott Shane, *When Do Start-ups that Exploit Patented Academic Knowledge Survive?*, 21 Int. J. Ind. Org. 1391, 1408 (2003); *see also* Scott Shane, *Technological Opportunities and New Firm Creation*, 47 Mgt. Sci. 205 (2001) (using data on inventions at MIT, "[c]ontrolling for who invented the technology, the characteristics of the industry, the time period when the technological development took place, and the nature of the technology, more important inventions, more radical inventions, and inventions with a broader scope of patent protection were more likely to be commercialized through the creation of new firms.").

performance.[356] Taking equity stakes in lieu of royalties appears to promote the creation of start-ups.[357] Similarly, permitting part-time employment at start-ups is valuable.[358] However, Lerner catalogs a variety of dangers for university-related start-ups in obtaining financing and for universities in establishing their own venture funding.[359]

Creating a start-up company requires complex connections with entrepreneurial, managerial, and financial resources.[360] Zahara, Van de Velde and Larrañeta propose that "a key source of the potential performance differences" among spinoffs "lies in their 'knowledge conversion capability' (KCC) that refers to their capacity to transform research and scientific discoveries into successful products and goods that are efficiently and quickly commercialized to create value," although they concede that there is little knowledge of how spinoffs accomplish KCC.[361] They suggest three key components: (1) "conceptualization and visioning", which "means envisioning and conceiving potential uses and applications for the new technology;" (2) "configuration and design", which "centers on developing working and functional prototypes that transform this knowledge into new products that are easy to develop and manufacture;" and (3) "embodiment and integration" that "denotes a firm's ability to integrate and apply diverse knowledge from different sources and convert its technology to marketable products."[362] Surveying firms in five states, they find that corporate spin-offs have

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[356] *See* Maryann Feldman, Irwin Feller, Janet Bercovitz & Richard Burton, *Equity and the Technology Transfer Strategies of American Research Universities*, 48 Mgt. Sci. 105, 106-107 (2002). Feldman, et al. describe TTOs' evolution from seeing equity as a last resort financing mechanism to seeing it as a useful tool in some instances. *Id*. at 109-110. In particular, equity stakes preserve the university's option value in the technology. *Id*. at 110.

[357] Dante Di Gregorio & Scott Shane, *Why Do Some Universities Generate More Start-ups Than Others?*, 32 Rsch. Pol'y 209, 224 (2003).

[358] Edward B. Roberts, *The Technological Base of the New Enterprise*, 20 Rsch. Pol'y 283, 297 (1991).

[359] Lerner, *supra* note 250, at 51-53.

[360] *See* Jean-Jacques Degroof & Edward B. Roberts, *Overcoming Weak Entrepreneurial Infrastructures for Academic Spin-off Ventures*, 29 J. Tech. Transfer 327, 340-341 (2004). One such complexity is that "the development of academic entrepreneurship abilities at the organizational level influences individual scientists and their perceptions." Grimaldi et al., *supra* note 221, at 1050.

[361] Shaker A. Zahra et al., *Knowledge Conversion Capability and the Performance of Corporate and University Spin-offs*, 16 Indus. & Corp. Change, 569, 570 (2007); *see also* Lockett, Wright & Franklin, *supra*, note 275, at 186-187.

[362] *Id*. at 574 (internal quotation marks omitted).

statistically significantly higher mean measures of all three KCC components.[363] They suggest this was because corporate spinoffs had better access to KCC-related skills (from their parent corporations) than university spinoffs.[364] A crucial step for universities is to bolster spinoffs' access to the KCC components.

University policies affect the likelihood of a start-up being a solution. Preferential treatment for those engaged in building start-ups, such as non-research leaves, temporary freezing of tenure clocks, and various recognition increase faculty willingness to take on such projects.[365]

University-related spinoffs can develop with one of the research team serving as CEO or an outsider with prior business experience taking on that role.[366] Relying on an academic entrepreneur rather than someone with business experience can bring more commitment to a new technology, but can mean the start-up lacks business knowledge and experience and may inappropriately focus the entrepreneur on the technology rather than the business aspects.[367] Some research suggests companies are more likely to grow substantially if the academic entrepreneur leaves the university.[368] Other research found that start-ups in a university incubator were slower to 'graduate' from the incubator if they had faculty members as part of senior management.[369] Franklin, Wright and Lockett surveyed universities with start-up experience and found that the more successful among them saw fewer disadvantages to having "surrogate entrepreneurs" manage the start-ups rather than the faculty member behind the technology.[370] The biggest challenge was locating appropriate surrogates.[371]

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[363] *Id*. at 589.

[364] *Id*. at 594.

[365] Fini, Grimaldi, Santoni & Sobrero, *supra* note 341, at 1115.

[366] There is some evidence that the location of the firm near the scientists involved is important in some circumstances. *See* David B. Audretsch & Paula E. Stephan, *Company-Scientist Locational Links: The Case of Biotechnology*, 86 Am. Econ. Rev. 641 (1996).

[367] Stephen J. Franklin et al., *Academic and Surrogate Entrepreneurs in University Spin-out Companies*, 26 J. Tech. Transfer 127, 128 (2001).

[368] *Id*. at 128 (citing Doutriaux)

[369] Rothaermel & Thursby, *Incubator firm failure or graduation? The role of university linkages*, *supra* note 287, at 1088.

[370] Franklin et al., *supra* note 367, at 138.

[371] *Id*. at 138; see also Lockett, Wright & Franklin, *supra* note 275, at 193.

As noted earlier, one approach to start-ups is to train the research team in entrepreneurial skills. "Academics are often highly dependent on others in their environment to supply the competencies needed to launch a new venture given the traditionally non-commercial environment in which they operate."[372] Some argue that training programs such as the NSF I-Corps do not adequately prepare researchers because they focus on starting a business "but don't necessarily teach them how to grow a business and manage a business."[373] One suggests that ten years of support would be needed, rather than just one year.[374]

Early-stage funding support makes a difference.[375] Support programs are complicated to design and administer. The earlier stage of much technology coming out of universities raises problems for securing financing because it causes an "information asymmetry [for investors] vis-à-vis the TTO and the investment manager. Valuation of patents or tacit knowledge at the early stage of product development is quite uncertain and poses particular problems for venture capital firms. This problem is exacerbated because there is typically little information about the acceptability of the product in the market or the size of the market."[376] At the same time, leveraging IP rights is increasingly important for emerging technology companies' funding strategies.[377] To fill the gap created by these difficulties, some European countries provide public funding for start-ups. One fear with such funding is that firms will be overfunded relative to their merits, leading to overvaluations that then hinder subsequent funding rounds from market sources.[378] A study of European university spinoffs found evidence to support this effect.[379]

Another support tactic is to increase entrepreneurial faculty opportunities to build social capital through pre-start-up connections with venture capitalists. Drawing on a dataset of MIT spinoffs, Shane and Stuart suggest that founders'

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[372] Rasmussen, Mosey & Wright, *supra* note 303, at 94.
[373] H.R. Tech & Innovation Hearing, *supra* note 14, at 59 (statement of Robert Rosenbaum, President & Exec. Dir., Md. Tech. Dev. Corp.).
[374] *Id*.
[375] H.R. Tech & Innovation Hearing, *supra* note 14, at 60 (statement of Kent Nisbet, Exec. Dir., Univ. of Mich. Tech. Transfer).
[376] Clarysse et al., *supra* note 50, at 612.
[377] Charlotte H. Copperthite & Michael J. Lerner, *Leveraging Intellectual Property to Obtain Financing in a Global Arena*, 2 J. World Intell. Prop. 1015, 1016 (1999).
[378] Clarysse et al., *supra* note 50, at 613-14.
[379] *Id*. at 633.

social capital as measured by pre-formation connections with venture capitalists improved university start-ups' success at funding.[380] Aldritch and Audretsch find that academics' social capital (such as membership on a scientific advisory board or co-authoring with an industry scientist) is associated with higher propensity to become an entrepreneur.[381] Examining data from start-ups from two European universities, Soetanto and van Geehuizen find the university networks aid in securing financing.[382]

Creating conditions that nurture start-ups is a complex problem not solved by throwing money at firms (although they appreciate it), providing training in finance, management, or accounting (although this is useful), or asking researchers to read Schumpeter. Environments that help start-ups flourish are analogous to a coral reef: a diverse ecosystem.[383] The coral reef metaphor is apt because start-ups are not homogenous.[384]

Nelson concludes his case study of a Stanford-related innovation with mixed results in commercialization by pointing to the need for better "alignment" between universities and those who can make commercialization a success:

> Rather than suggesting that "firms are better at innovation than universities," "small firms are better at innovation than large firms," or "entrepreneurial innovation plays a more important role [than] structural innovation in universities," the present case points to the need to seek alignment between technological, organizational, institutional (and likely national) contexts – for it is in leveraging context and in

[380] Scott Shane & Toby Stuart, *Organizational Endowments and the Performance of University Start-ups*, 48 Mgt. Sci. 154, 168-169 (2002).

[381] Aldridge & Audretsch, *supra* note 230, at 1065-66.

[382] Danny Soetanto & Marina van Geenhuizen, *Getting the Right Balance: University Networks' Influence on Spin-offs' Attraction of Funding for Innovation*, 36-37 Technovation 26, 26 (2015).

[383] Gregory P. Pogue et al., *Building an Innovation Coral Reef: The Austin Technology Incubator Case Study*, *in* Open Innovation 203 (Arthur B. Markman, ed., 2016); Powers & McDougall, *Policy Orientation*, *supra* note 180, at 1039-1040 (discussing importance of local environment to success of spinoffs); Rory O'Shea et al., *Universities and Technology Transfer: A Review of the Academic Entrepreneurship Literature*, 25 Irish J. Mgt. 11, 19-20 (2004).

[384] Celine Druilhe & Elizabeth Garnsey, *Do Academic Spin-Outs Differ and Does it Matter?*, 29 J. Tech. Transfer 269, 269 (2004).

> recognizing where each context excels that we may hope to further both innovation and excellence in other university activities.[385]

This is a central issue for universities: how to harness resources to improve the flow of ideas from lab to market. It also highlights the central flaw in the Bayh-Dole approach of relying on universities to undertake a role for which they are ill-equipped.

Conclusion

To economists, the production of innovation by firms is still mostly a black box. How they generate research is not well understood. A few universities claim a significant role in innovation. There are touted successes: Gatorade (University of Florida) and the Moderna COVID-19 vaccine (MIT). These are not sufficient to allow us to know if universities play a major role in innovation; given the $50 billion spent by the NSF and NIH in 2021 alone, there should be many significant successes. Yet the data on university patents suggests that most universities are not engaged in this important preliminary step on the road to commercialization of research.

This Article provides insights into the red box innovation processes in non-profit universities that policymakers generally want to play a bigger role in successful research. Universities do offer an environment that businesses believe has advantages for at least certain types of research. Some of the most successful corporate laboratories mimicked university environments and those who have worked in them and studied them point to those features as critical to their successes. If we could do a better job of engaging universities in producing commercializable ideas – the first step toward which is more patenting of ideas from research – we might be able to unlock more of the benefits the proponents of Bayh-Dole promised the statute would deliver. However, universities are inherently conservative organizations, not prone to radical changes in structure. Nonetheless, from what we know of successful processes, some changes on the margins could improve university performance in commercialization.

Schumpeter put innovation in the center of his approach to economics, calling it a "third and logically distinct factor in economic change" (alongside the "non-

385 Andrew J. Nelson, *From the ivory tower to the startup garage: Organizational context and commercialization processes*, 43 Rsch. Pol'y 1144, 1154 (2014).

cyclical element of growth" and "outside factors"), arguing that "If there be a purely economic cycle at all, it can only come from the way in which new things are, in the institutional conditions of capitalist society, inserted into the economic process and absorbed by it."[386] It drove the "incessant *creation* of new plant and equipment, embodying new technologies that revolutionize existing industrial structures"[387] producing "great surplus gains" from new industries and methods.[388]

As generators of ideas and of research likely to teach us how to "do new things" and "new ways of doing things," universities are a source of Schumpeterian innovation. But innovations have impact only if they reach the market. If we are to benefit more from investments of university researchers' effort, we need a better approach to moving ideas from lab to market. Approaching that problem with a Schumpeterian/Kirznerian view is one way. O'Kane *et al.* argue that TTOs struggle with contradictory identities, caught between a need for a scientific identity to connect with their faculty clients and a business identity to connect with university administration and potential licensees.[389] Having a clear framework for their mission could help accomplish that. Developing that framework requires universities to reject the anti-capitalist ideas so common in academia and encourage researchers to meet market tests of value. Another step may be to fill more positions with people with entrepreneurial experience. This would require universities to consider entrepreneurial skills and interests in hiring research faculty.

At a more mundane level, better data on university efforts at commercialization is needed.[390] We need to understand which technologies successfully move out of the university into the market, which faculty are more likely to be successful, and

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[386] Joseph A. Schumpeter, *The Analysis of Economic Change*, *reprinted in* ESSAYS ON ENTREPRENEURS, INNOVATIONS, BUSINESS CYCLES, AND THE EVOLUTION OF CAPITALISM 139 (Richard Clemence, ed., 2008) (1935) [hereinafter Schumpeter, *Economic Change*].

[387] Schumpeter, *Capitalism Essay*, *supra* note 32, at 198.

[388] Schumpeter, *Economic Theory and Entrepreneurial History*, *supra* note 32, at 258. Arguably, the most successful implementation of a Schumpeterian approach to economic growth came in the Asian Tiger economies, where there was "an extraordinary emphasis on saving and investment, a broad range of innovation across many industries, and a tremendous outburst of entrepreneurship in new companies . . ." MCGRAW, *supra* note 30, at 182.

[389] Conor O'Kane, Vincent Mangematin, Will Geoghegan & Ciara Fitzgerald, *University Technology Transfer Offices: The Search for Identity to Build Legitimacy*, 44 RSCH. POL'Y 421, 428-429, 432 (2015).

[390] Perkmann et al., *Academic Engagement & Commercialization*, *supra* note 111, at 430-31. We are working on an extension of this project with additional coauthors, seeking to map which areas universities are patenting in and how their success compares to patents from other sources.

which forms of commercialization work best for various technologies. Better data includes better measures of success as well as more data on efforts at innovation.

The editors of a special issue of the *Journal of Economic Behavior and Organization* looked at academic science's relationship with entrepreneurship. Its overarching theme was that there are tradeoffs, "including the opportunity cost of searching for (and negotiating with) industrial partners, the shift in the time horizon and direction of research, and the distortions induced by limiting the dissemination and future use of research findings," involved in commercialization efforts.[391] Broader recognition of these tradeoffs by universities is essential.

Schumpeter argued that innovations tended to "*cluster* at certain times" because "as soon as the various kinds of social resistance to something that is fundamentally new and untried have been overcome, it is much easier not only to do the same thing again but also to do *similar* things in different directions, so that a first success will always produce a cluster."[392] Universities support researchers from a range of disciplines. They are positioned to consider not just the technologies that produce these clusters but to analyze the development and impacts of these clusters. A focus on technologically driven clusters would likely yield more innovation, thereby enhancing the value of universities to society.

"Most innovations…especially the successful ones, result from a conscious, purposeful search for innovation opportunities."[393] Innovations rarely result from flashes of inspiration. Paul McCartney woke up one day with the melody for the song "Yesterday" in mind, but then worked to perfect it for two years. It was "hard grueling work," not "sudden creative genius,"[394] that produced the successful version. So, too, it is with researchers inside the red boxes. Long work based on expertise is required and results are not guaranteed. University researchers help develop innovations that spur the economy. If we could do better than Bayh-Dole has done at encouraging such efforts, society as a whole would benefit. The process that has arisen to try to sell inventions to the private sector, usually through TTOs,

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[391] Adam Jaffe, Josh Lerner, Scott Stern & Marie Thursby, *Academic Science and Entrepreneurship: Dual Engines of Growth?*, 63 J. Econ. Behav. & Org., 573, 575 (2007).

[392] Schumpeter, *Economic Change*, *supra* note 386, at 141-42.

[393] Peter Drucker, *The Discipline of Innovation*, Harv. Bus. Rev. 95, 96 (Aug. 2002).

[394] Allen Gannett, the Creative Curve: How to Develop the Right Idea, at the Right Time 8 (2018).

ultimately needs to incorporate the insights Schumpeter and Kirzner developed on entrepreneurship. If they do so, they will be more successful at the process of moving new things into the market. We should care about how the products of university research move from the lab to the economy because, as Kealey says, "technology *is* wealth."[395] More than forty years of Bayh-Dole's inadequate linear model of innovation is enough. It is time for a serious effort to rethink how universities can best foster innovation and so create economic growth.

[395] KEALEY, *supra* note 12, at 205. Kealey makes a persuasive case that governments need not fund even basic research, a separate question from that addressed in this Article. *Id*. at 216-234.