The Pull of Patents*

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ABSTRACT:

The conventional view of the role of patents in the university research context (and more generally) is that patent-enabled exclusivity improves the supply-side functioning of markets for university research results (and inventions more generally) as well as those markets further downstream for derivative commercial end-products. The reward, prospect, and commercialization theories of patent law take patent-enabled exclusivity as the relevant means for fixing a supply-side problem—the undersupply of private investment in the production of patentable subject matter or in the development and commercialization of patentable subject matter that would occur in the absence of patent-enabled exclusivity. Put another way, patents attract private investment to productive activities that might otherwise be less attractive investments. The reason why is rather straightforward and well-understood. Without patents, the fruits of the investments, intellectual fruit, would be too easily accessed and used by others without compensation to the original investor, thus undermining the incentive to invest in the first place. This is the standard public goods story that serves as the textbook explanation for why we have a patent system.

While the supply-side view of the role of patents is important, a view from the demand-side is needed to fully appreciate the role of patents in the university research context (and more generally) and to fully inform university decisions about the extent to and manner in which they participate in patenting and commercializing research. Introducing patents into the university research system, along with a host of other initiatives aimed at tightening the relationship between universities and industry, is (primarily) aimed at increasing connectivity between university science and technology research systems and the demands of industry for both university research outputs (including research results and human capital) and upstream infrastructural capital necessary to produce such outputs.

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In this essay, I explore how university science and technology research systems perform economically as infrastructural capital and explain how these systems generate social value. I explain the dual role of patents in the university research context. On the supply side, patents facilitate the transfer (or "push") of university research to industry. On the demand side, patents attract (or "pull") university resources to meet industry demands. I focus on the demand side dynamic and explain how "patent pull" in the university research context may lead to a slow and subtle shift in the allocation of critical infrastructure resources within universities. I explore what this means for both universities and society, and conclude with some observations about how universities might approach these issues strategically.

Approaching the role of patents from the demand side is an entirely new enterprise, and it is critical to understanding the role of patents in the university context and more generally. Thus, in conclusion, I also make a few suggestions about future avenues of research in this area.

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I. INTRODUCTION

There are substantial, growing literatures debating the merits of commercializing universities and university research.[1] The legal and economic literatures in particular focus extensively on university research results, and most often on how research results are managed, developed, licensed, transferred, priced, and used.[2] The use of patents within the university research system as a tool to encourage and indeed enable technology transfer, utilization and commercialization has been lauded by some as a major success and criticized by others as a major failure. Those who claim success focus on increased rates of patenting, licensing and commercialization.[3] Patents encourage and enable transactions; they serve as the focal point for researchers, technology transfer officers, lawyers, venture capitalists, entrepreneurs, engineers, marketers, and other participants in the commercialization process. Without patents, the proponents argue, potentially valuable research languishes underutilized.[4] On the

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[1] Not surprisingly, different literatures approach the commercialization question from different perspectives, some focusing broadly on the university on the whole and others focusing more narrowly on university research. As a law professor who teaches and writes about the law and economics of intellectual property, I approach the debate, at least initially, from the legal and economic literatures and with a focus on the role of patents on university research. As I explain below, however, I propose a new and important, intermediate level of analysis—in between university-focused and university research-focused—that considers commercialization of the *university science and technology research system.* I do not delve into the literature on institutional resource allocation, which focuses on the allocation of resources among university departments. *See* Cindy S. Volk et al., *Models of Institutional Resource Allocation: Mission, Market, and Gender*, 72 J. HIGHER EDUCATION 387 (2001).

[2] The economic and legal literatures are voluminous. *See, e.g.,* David C. Mowery, Richard R. Nelson, Bhaven N. Sampat and Arvids A. Ziedonis, IVORY TOWER AND INDUSTRIAL INNOVATION: UNIVERSITY-INDUSTRY TECHNOLOGY TRANSFER BEFORE AND AFTER THE BAYH-DOLE ACT (2004); DEREK BOK, UNIVERSITIES IN THE MARKETPLACE, (Princeton University Press 2003); BRANSCOMB, ET AL., INDUSTRIALIZING KNOWLEDGE (1999); ETZKOWITZ, ET AL., CAPITALIZING KNOWLEDGE (1998); HENRY ETZKOWITZ, MIT AND THE RISE OF ENTREPRENEURIAL SCIENCE (2002); GROSS, NEW IDEA FACTORY (2000); Ajay Agrawal, *University-to-industry knowledge transfer: literature review and unanswered questions*, I.J.M.R. (Dec. 2001); Cohen, W., R. Florida, L. Randazzese, and J. Walsh, *Industry and the Academy: Uneasy Partners in the Cause of Technological Advance*, *in* CHALLENGES TO THE RESEARCH UNIVERSITY (R. Noll, ed., 1998); Rebecca Eisenberg, *Proprietary Rights and the Norms of Science in Biotechnology Research*, 97 YALE L. J. 177 (1987); Rebecca Eisenberg, *Patenting the Human Genome*, 39 EMORY L. J. 721 (1990); Rebecca S. Eisenberg, *Public Research and Private Development: Patents and Technology Transfer in Government-Sponsored Research*, 82 VA. L. REV. 1663 (1996); Arti Rai, *Regulating Scientific Research; Intellectual Property Rights and the Norms of Science*, 94 NW. U. L. REV. 77 (1999); Brett Frischmann, *Innovation and Institutions: Rethinking the Economics of U.S. Science and Technology Policy*, 24 VT. L. REV. 347 (2000); F. Scott Kieff, *Property Rights and Property Rules for Commercializing Inventions*, 85 MINN. L. REV. 697 (2001); J.H. Reichman & Paul F. Uhlir, *A Contractually Reconstructed Commons For Scientific Data in a Highly Protectionist Intellectual Property Environment*, 66 L. & CONTEMP. PROBS. 315 (2003).

[3] *See generally* BOK, *supra* note 2 (arguing that the Bayh-Dole Act and patents enabled universities to do a better job serving the public interest).

[4] *See id.*; Kieff, *Property Rights and Property Rules*, *supra* note 2 (arguing that the primary role of patents is to facilitate commercialization).

other hand, those who claim failure focus on transaction costs, patent "thickets," deadweight losses, increased costs to the public, increased secrecy, and shifts in academic norms.[5] Patents, they argue, are unnecessary impediments to widespread, competitive utilization of research results that the public already has paid for.[6]

This debate is by no means resolved. Its resolution will depend upon continued empirical testing of the various types of costs and benefits that each side has highlighted. Moreover, the strength of the arguments offered by each side will vary considerably across research areas (for example, compare computer science, biotechnology and materials science) and across research result types (for example, compare upstream basic research, midstream research tools, and downstream commercial technology).[7] With the exception of some discussion of academic norms, most of the attention in this debate within the legal literature is focused on research results—the outputs from the research process.[8]

In this essay, I shift focus away from the management of outputs. That is, I will not address the arguments noted above about whether patents improve or worsen dissemination and use of university research results. Instead, I focus on the manner in which patents affect (i) the type or nature of the outputs produced; (ii) the process of research and other related university-based processes; and mostly, even further upstream, (iii) the university science and technology research system itself. As explained in more detail below,

> *<u>university science and technology (S&T) research system</u> refers to the system of complementary university resources—financial, governance, human, intellectual, and physical capital resources—that together act as inputs into different types of productive processes—including research, education, training, and socialization—that generate a wide range of socially valuable research outputs—intellectual and human capital (research results and skilled people).*

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[5] *See* Eisenberg, *Proprietary Rights*, *supra* note 2; *see also* Eisenberg, *Patenting the Human Genome*, *supra* note 2, at 738 (discussing the possible costs and benefits of providing patents for publicly funded research of human genomes); Rai, *Regulating Scientific Research, supra note 2, at* 88; Reichman & Uhlir, *A Contractually Reconstructed Commons*, *supra* note 2, at 320 (recognizing increased intellectual property rights discourage traditional sharing of scientific findings).

[6] *See* Frischmann, *Innovation and Institutions*, *supra* note 2; *see also* Brett Frischmann & Mark Lemley, *Spillovers*, Working Paper (2005) (discussing the advantages of widespread competitive utilization over coordination).

[7] *See* Dan L. Burk & Mark A. Lemley, *Policy Levers in Patent Law*, 89 VA. L. REV. 1575, 1600-15 (2003) (discussing how different theories are more relevant to different industries depending on a particular industry's needs and capabilities).

[8] *See* Brett Frischmann, *A Process-oriented View of Intellectual Property*, Working Paper (2005-06) (arguing that intellectual property law and scholarship tends to be "output-focused" and pays insufficient attention to the intellectual processes that yield outputs).

While patent scholars debate the impact of patents on the management of university research, they pay scant attention to potential impacts of patents on the university research system itself. This essay, by contrast, draws attention to the role of patents in commercializing the university S&T research system.

Given limits in government funding of research, universities have begun to pursue and employ patents aggressively to transfer technology, encourage entrepreneurship and generate revenues that may support research efforts. While some universities have found tremendous success in pursuing commercial avenues, the vast majority have not.[9] Yet many still continue to make participation in the patenting and commercialization process a priority.[10]

Universities face incredibly difficult, complex decisions concerning the degree to which they ought to participate in commercialization of research.[11] While limited government funds may be the immediate, most visible factor forcing such decisions upon universities,[12] there are more fundamental forces at work. In *Academic Capitalism*,[13] Sheila Slaughter and Larry Leslie present a compelling argument that globalization, changing economic conditions, and other macro-level factors are increasing pressure on universities on the whole to behave more and more like market actors.

Another (complementary) explanation can be found in the dominant economic mindset that has emerged in the past few decades. This mindset

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[9] *See* Jay Kesan, *Tech-Transfer Offices As Intermediaries (On Their Own Terms)*, Working paper, presented at W(h)ither the Middleman: The Role and Future of Intermediaries in the Information Age, Michigan State University College of Law, April 8-9, 2005, East Lansing, Michigan (analyzing success rates and trends in patenting behavior at U.S. universities); Aldo Geuna & Lionel Nesta, *University patenting and its effects on academic research. The emerging European evidence*, RESEARCH POLICY (forthcoming 2005) (analyzing success rates and trends in patenting behavior at European universities).

[10] *See* Kesan, *supra*; NATIONAL SCIENCE FOUNDATION REPORT, ACADEMIC PATENTING: PATENTS AWARDED TO U.S. UNIVERSITIES, (1996), *available at* http://www.nsf.gov/sbe/srs/seind96/ch5_acad.htm (same); Rebecca Henderson, et al., *Universities as a Source of Commercial Technology: A Detailed Analysis of University Patenting, 1965-1988* 80 REVIEW OF ECONOMICS AND STATISTICS 119 (1996).

[11] *See* SHEILA SLAUGHTER & LARRY LESLIE, ACADEMIC CAPITALISM (1997); James Stuart, *The Academic-Industrial Complex: A Warning to Universities*, 75 U. COLO. L. REV. 1011, 1042 (2004); *see generally* Jennifer Croissant & Sal Restivo, DEGREES OF COMPROMISE: INDUSTRIAL INTEREST AND ACADEMIC VALUES (SUNY Press 2001).

[12] Committee on Trends in Federal Spending on Scientific and Engineering Research, Board on Science, Technology and Economic Policy, National Research Council, TRENDS IN FEDERAL SUPPORT OF RESEARCH AND GRADUATE EDUCATION, 21-44 (2001), National Academies Press, *available at* http://www.nap.edu/nap-cgi/skimit.cgi?isbn=0309075890&chap=21-48; *see also The NSF Budget: How Should We Determine Future Levels?: Hearings Before the Subcomm. on Res. Committee. on Sci. House of Rep.*, 107th Cong. 107-62 (2002) 11-13 (discussing the drop in funding for the National Science Foundation).

[13] SLAUGHTER & LARRY LESLIE, *supra* note 11.

focuses on the perceived social benefits of commercialization, privatization and deregulation, on minimizing government intervention in markets, and arguably on maximizing market intervention into government and academia, although proponents of such increased reliance on the market mechanism would not put it this way.[14] As Paul Krugman recently noted, "Decades of conservative marketing have convinced Americans that government programs always create bloated bureaucracies, while the private sector is always lean and efficient."[15] In my opinion, universities often are typecast like government in a manner that marginalizes their social and economic contributions and their respective roles in society. Along with a glorified view of the market and a pessimistic view of government, universities are cast as ivory tower havens for (liberal) academics out of touch with reality and the demands of society.

This is not the place to develop these arguments fully, but I raise them to suggest that the commercialization question is not unique to the university research context but rather is endemic to evolving notions of modern societal organization in capitalist economies.[16] To grapple with the commercialization question, universities should step back from their immediate context, compare their situation with that of other industries and social contexts, reflect on their role in society, and proceed carefully.

In this essay, I explore how university science and technology research systems perform economically as infrastructural capital, explain how these systems generate value, and help reframe the commercialization question. I explain the subtle demand-side role of patents in the university science and technology research system and how the availabilityof patents , coupled with scarce government funding, may lead to a creeping systemic optimization—a slow and subtle shift in the allocation of infrastructure resources and research

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[14] In his book, *MIT and the Rise of Entrepreneurial Science*, Henry Etzkowitz suggests that "reorient[ing] the universities toward a commercial role was not intervention in the sense of specific government measures requiring targeting of particular areas of R&D for support, as in Japan, or requiring enterprises and research institutes to make research contracts with each other, as in the Eastern European socialist model. Instead, incentives were built into the research-funding system to move universities closer to industry, in their motivation and structure." ETZKOWITZ, MIT AND THE RISE OF ENTREPRENEURIAL SCIENCE, *supra* note 2, at 125. Etzkowitz is reassured that the government is not overtly intervening into academia, but fails to appreciate fully the risks of industry intervention, which I discuss below.

[15] *Buying Into Failure*, NY Times, Op. Ed. (Dec. 17, 2004).

[16] In three previous articles, I have argued that the dominant economic mindset ignores critical social and economic values and that over-reliance on the market mechanism may involve significant social (opportunity) costs that escape consideration within conventional economic analyses. In these articles, I used the tools of the economics discipline to challenge the dominant economic mindset as it pertains to specific areas. *See* Frischmann, *Innovation and Institutions: supra* note 2; Brett Frischmann, *Privatization and Commercialization of the Internet Infrastructure: Rethinking Market Intervention into Government and Government Intervention into the Market*, 2 COLUM. SCI. & TECH. L. REV. 1, 51 (June 8, 2001) at http://www.stlr.org/cite.cgi?volume=2&article=1 (last visited Dec. 14, 2004); Brett Frischmann, *An Economic Theory of Infrastructure and Commons Management*, 89 MINN. L. REV. 917 (2005).

priorities. This optimization is not simply an adjustment in incentives, an "incentive shift" for researchers to "better" align their incentives with the commercialization objective and thereby encourage more efficient technology transfer, which boils down to more efficient *supply* of university derived technology to downstream commercial markets. While this is part of the dynamic, it is critical that universities take a wider view and recognize the demand-side effects of commercialization.

The role of patents in the university research context (and the commercialization question more generally) is not simply about using patent-enabled exclusivity to fix the supply-side problem of underutilization of government funded research results; it is also if not primarily about increasing connectivity between university science and technology research systems and the *demands* of industry for both university research outputs (research results and human capital) and the infrastructural capital necessary to generating those outputs.

The U.S. government has made an explicit policy decision to allow funded entities to obtain patents and thereby has encouraged participation in the commercialization of federally funded research. The Bayh-Dole Act[17] enables universities to participate in the commercialization process, but it does not obligate or constrain them to pursue any particular strategy with respect to federally funded research.[18] Universities must decide carefully the extent to which they wish to participate in the commercialization process.[19] As Richard Florida has argued, "universities need to be more vigilant in managing the process" and should "reconsider their more aggressive policies toward technology transfer and particularly regarding the ownership of intellectual property."[20] Universities remain in the driver's seat and may decide which road to take and at what speed.

The remainder of the essay is organized as follows: Part II discusses university science and technology research systems and explains how they perform economically [as infrastructural capital]. Part III explains how patents were introduced based on "supply-side" reasoning without due care for "demand-side" issues. It then describes how patents create a demand-pull for optimization created by market-driven incentives in the university research context. Part IV suggests that universities have a choice and must carefully decide on the degree to which they participate in commercialization. Part V concludes.

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[17] Bayh-Dole University and Small Business Patent Procedures Act, Pub. L. No. 96-517, 94 Stat. 3019 (codified as amended at 35 U.S.C. §§ 200Œ 211) (2000).

[18] *C.f.* Eisenberg, *Public Research and Private Development*, *supra* note 2, at 1700 (noting that university support for the Bayh-Dole Act was in part due to their ability to control their interactions with commercial entities).

[19] *See* Rai, *supra* note 2.

[20] Richard Florida, *The Role of the University: Leveraging Talent, Not Technology*, SCIENCE AND TECHNOLOGY ONLINE (Summer 1999), at http://www.isues.org/issues/15.4/florida.htm.

II. UNIVERSITY SCIENCE AND TECHNOLOGY RESEARCH SYSTEMS

A university science and technology research system is a system of productive resources aggregated within a university setting and used to produce a stream of research-related outputs.[21] The system is comprised of at least five different sets of related, complementary resources, including:

1. *human capital*, including complementary networks of people such as professors, researchers, students, administrators, technicians, and other support staff;[22]
2. *governance capital*, such as rules, norms, policies and other collective constraints that guide system participants' behavior;
3. *physical capital*, such as land, facilities and equipment;
4. *intellectual capital*, such as knowledge, information, and ideas;[23] and
5. *financial capital*.

Each of these capital resources is an essential component of the system, although the bundle of such resources and manner in which they are bundled varies considerably across universities. I have referred to the various components of the system as *capital* because, aggregated together within a university, these resources are used collectively and continuously as inputs into a variety of production processes, including research, education, training, and socialization, among others.

[insert Figure One (at the end)]

These production processes yield a wide variety of research-related outputs, which can be grouped into two major categories—intellectual capital and human capital. Intellectual capital outputs[24] are the intangible information goods,

[21] Of course, these resources also produce other important outputs as well, *e.g.,* educated citizens.

[22] Florida focuses on the importance of attracting and aggregating human capital within the university science and technology system as a means of improving its performance. He notes that universities must attract the "top talent," referring to academic research professors, in order to attract the top graduate students. Florida emphasizes the need to shift our myopic focus on research results (e.g., university derived invention) to human capital, in terms of both human capital outputs and human capital as a component of infrastructural capital. *See* Florida, *The Role of the University*, *supra* note 20.

[23] The intellectual capital category is meant to capture the full range of intangible products of the human intellect, regardless of whether the product has been fixated in a tangible medium (i.e., written down) and regardless of whether any particular entity claims ownership of the intellectual good. Intellectual capital often overlaps significantly with human capital. For example, the idea residing in the mind of a professor is an intellectual resource while the professor is a human capital resource.

[24] I recognize that the term "capital outputs" seems like an oxymoron, but it is not. It is important to realize that capital goods are produced and thus are outputs of a production process, especially when evaluating streams of cumulative input-output relationships.

essentially the research results, which may or may not be embedded in some artifact (e.g., equipment design), be fixated in some tangible form (e.g., written down), or simply reside in the minds of researchers. Generally, when we refer to "science," "research," "invention," "innovation," "technology," and so on, we are talking about various types of intellectual capital that are outputs from some intellectual process. These outputs are public goods with varying potential to yield positive externalities (or conversely, appropriable benefits) when utilized productively further downstream. The types of downstream uses may vary considerably, and so can the variance itself.[25]

Equally if not more important than pure intellectual capital outputs—*research results*—are human capital outputs—*people with (a) higher levels of education, knowledge, experience, and research-oriented skills (b) who are prepared for entry into the research community*.[26] The importance of human capital outputs is well-understood. Many commentators, such as Richard Florida, have emphasized the critical role of U.S. universities in educating and training (graduate) students—in creating "talent" that fuels the knowledge economy. Education, knowledge, experience, and research-oriented skills must be absorbed by students and consequently often are standard (in contrast with the cutting edge nature of the research result outputs). Once absorbed through the processes of research, education and training, the intellectual capital residing within the university science and technology research system is disseminated and shared. Thus, research-oriented education, knowledge, experience, and skills may be viewed as forms of intellectual capital that are disseminated to students and used productively to augment their human capital.

Both intellectual and human capital outputs generate value when used productively as inputs downstream. As Figure Two illustrates, "downstream" use of these outputs may entail use in further research (internally or externally) or use in commercialization processes (internally or externally).

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[25] *See* Frischmann, *Innovation and Institutions*, *supra* note 2.

[26] It is important to realize that socialization is an important aspect of the university science and technology research system. Students are prepared for entry into the research community, for example, by gaining familiarity with professional norms and ethics and forming relationships with members of the community. Most undergraduate or graduate students have limited real-world experience and very little (if any) experience in dealing with professionals *as a member of the professional community*. In law school, for example, we place a significant emphasis on the fact that students will be entering a profession, that they will be members of the bar, and that a host of ethical and even less formal community norms apply to members. The law school experience, in part, consists of a socialization process that prepares the students for professional membership. A very similar dynamic exists within the university research setting, although it is less explicit and less formal than in the law school setting. Katherine Strandburg has indirectly touched on this dynamic. She explores the relationships between community norms and academic scientists' individual preferences. *See* Katherine Strandburg, *Curiosity-driven research and university technology transfer, in* 16 UNIVERSITY ENTREPRENEURSHIP AND TECHNOLOGY TRANSFER: PROCESS, DESIGN, AND INTELLECTUAL PROPERTY, ELSEVIER SCIENCE/JAI PRESS SERIES: ADVANCES IN THE STUDY OF ENTREPRENEURSHIP, INNOVATION, AND ECONOMIC GROWTH (2005).

[insert figure two (at the end)]

For the most part, then, universities are "vertically integrated" with respect to the production of research systems and research-related outputs; some outputs are consumed internally while others are consumed externally. The manner in which the outputs are used depends, of course, on the nature of the specific outputs.

Viewed as an integrated system of complementary resources that generate value primarily when used to produce a stream of research-related outputs, the university science and technology research system begins to look like other forms of infrastructural capital.[27]

University science and technology research systems are "sharable" in the sense that multiple users may access and use the system resources to engage in productive processes and produce research-related outputs.[28] Some components of the system have infinite capacity (*i.e.,* are purely nonrival in consumption)—such as intellectual and governance capital—while others have finite capacity (*i.e.,* are rival in consumption)—such as physical, financial, and human capital. It is the scarcity of these latter types of capital resources that drives both competition for funding and prestige and resource allocation decisions. As discussed below, to some extent, the rivalrousness[29] of the system is what puts pressure on universities to optimize the system for commercial outputs because the appropriable benefits (revenues) generated by such outputs may provide the resources necessary to sustain the system. (More on this dynamic below.)

University science and technology research systems, like road systems, basic research, the Internet and many infrastructures,[30] are socially valuable primarily because of the productive activity they facilitate downstream. In other words, the value created by these research systems is only realized when the

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[27] *See* Frischmann, *Economic Theory of Infrastructure*, *supra* note 16 (on different types of infrastructure capital).

[28] *See id.*, at 956-57, 959 (explaining the economic significance of this characteristic); Brett M. Frischmann, *Peer-to-Peer Technology as Infrastructure: An Economic Argument For Retaining Sony's Safe Harbor For Technologies Capable of Substantial Noninfringing Uses*, 52 J. COPYRIGHT SOCIETY 329, 332-33 (2005) (same); *see also* Yochai Benkler, *Coase's Penguin, or, Linux and the Nature of the Firm*, 112 YALE L.J. 369 (2002) (on a particular class of sharable goods); Yochai Benkler, *Sharing Nicely: On shareable goods and the emergence of sharing as a modality of economic production*, 114 YALE L.J. 273 (2005).

[29] *See* Jonathan M. Barnett, *Private Protection of Patentable Goods*, 25 CARDOZO L. REV. 1251, 1257 (2004) (Barnett describes the "first-mover" concept in which the first party to develop a new innovation employs different economic tactics to maintain its market monopoly). *See also* Katherine Strandburg, *What Does the Public Get? Experimental Use and the Patent Bargain*, 2004 WIS. L. REV. 81, 85-6 (2004) (Strandburg explains that due to the Bayh-Dole Act and the relationship between federally funded researchers and private actors "provides opportunities for strategic behavior, such as firms' placing of particular research projects into the nonprofit sector so as to gain access to the patented technology of competitors.")

[30] Frischmann, *Economic Theory of Infrastructure*, *supra* note 16.

research-related outputs are used downstream; essentially, the "value added" is embedded in the outputs. Accordingly, to fully understand the social demand for this type of infrastructure and to assess how well demand signals "manifest" upstream,[31] it is necessary to evaluate the output markets in terms of the nature of the outputs produced, the extent to which such outputs generate (non)observable and (non)appropriable value, and the manner in which value is distributed (for example, is value realized only by consumers or are there external benefits to nonconsumers).

Most university science and technology research systems served *mixed* commercial, public, and social ends by enabling the downstream production of a wide variety of private, public, and non-market goods. As a general matter, university science and technology research systems do not directly yield private goods for commercial markets (except to the extent that one takes the view that human capital outputs constitute rival goods consumed in the labor market), although these systems generate human and intellectual capital that may be used externally to produce such goods.

University science and technology research systems produce a wide array of public and non-markets goods that generate (or have the potential to generate) significant positive externalities. This should not be a controversial point. It is important to realize, however, that the human and intellectual capital outputs of these systems have varying potentials to yield positive externalities and, conversely, appropriable benefits. This variance can be understood in a few ways. For a moment, put aside human capital outputs[32] and focus on intellectual capital outputs—research results that are pure public goods. The research results may vary in terms of their genericness-specificity with respect to applications downstream—that is, they may vary along the basic to applied continuum.[33] The research results also may vary in terms of the classes of applications—for example, commercial, private goods production or noncommercial research. Both types of variance affect the potential for positive externalities and appropriable benefits.

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[31] I discuss demand manifestation below and extensively in *An Economic Theory of Infrastructure and Commons Management*. *See id.*

[32] Human capital outputs also may exhibit variance in the potential to generate positive externalities. To see how, consider the various production processes within the university science and technology research system that "produce" human capital outputs—specifically, research, education, training, and socialization.

[33] J. H. Reichman & Paul F. Uhlir, *A Contractually Reconstructed Research Commons for Scientific Data in a Highly Protectionist Intellectual Property Environment*, 66 LAW & CONTEMP. PROBS. 315, 332 (2003) (Federal grants for basic research is one method by which such government-funded research "enter[s] the upstream processes of scientific research as an input available from the public domain.")

As a general matter, most universities do not allocate their infrastructural capital on the basis of commercial prospects in output markets.[34] Consequently, the range of outputs from university science and technology research systems has not historically been weighted more heavily towards commercial research. This is not to say that universities have not made significant contributions in the realm of commercial research—of course, they have[35]—but rather commercial applications have not generally been a central objective or priority. Put another way, industry demand for commercializable research has not driven universities' resource allocation decisions—at least, historically.

By the same token, again historically, government research funding has not been weighted more heavily towards specific commercial ends.[36] Yet, at times, government-funding has yielded research with commercial applications, and, as the history behind the Bayh-Dole Act tells us,[37] such research was (allegedly) underutilized.[38] To solve this problem of underutilized government-funded research, intellectual property took on a new role, to which I now turn.[39]

III. THE ROLE OF PATENTS IN UNIVERSITY RESEARCH SYSTEMS

There are many competing theories, justifications, and explanations for the existence of intellectual property law. The dominant economic justification for patents outside the university research context is that granting patents over

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[34] As Auerswald and Branscomb note, researchers tend to allocate their resources—time, money, graduate student assistance, etc.—according to their "*interest* in the question posed" which "contrast[s] sharply with a decision rule based on commercial potential." Philip E. Auerswald & Lewis M. Branscomb, *Start-ups and Spin-offs: Collective Entrepreneurship Between Invention and Innovation*, *in* THE EMERGENCE OF ENTREPRENEURSHIP POLICY 61, 79-80 (Ed., David M. Hart 2003). They also note: "A fundamental challenge involved in taking a project from invention to innovation is accomplishing the shift from decisions based on the criterion of 'interestingness' to one based on the criterion of commercial value."

[35] *See, e.g.,* Rebecca Henderson, et al., *Universities as a Source of Commercial Technology: A Detailed Analysis of University Patenting, 1965-1988*, 80 REVIEW OF ECONOMICS AND STATISTICS 119 (1996).

[36] Traditionally, federal research funding has primarily been mission-oriented. *See* DONNA FOSSUM ET AL., VITAL ASSETS: FEDERAL INVESTMENT IN RESEARCH AND DEVELOPMENT AT THE NATION'S UNIVERSITIES AND COLLEGES 2 (RAND 2004). Recent studies suggest that federal R&D funds have become increasingly concentrated. *Id.* at 12 (recent increases in R&D funding to universities and colleges has been highly focused on medical research).

[37] *See* David C. Mowery, Richard R. Nelson, Bhaven N. Sampat and Arvids A. Ziedonis, IVORY TOWER AND INDUSTRIAL INNOVATION: UNIVERSITY-INDUSTRY TECHNOLOGY TRANSFER BEFORE AND AFTER THE BAYH-DOLE ACT (2004).

[38] *See* Eisenberg, *Public Research and Private Development*, *supra* note 2, at 1702 (discussing and critiquing the argument that federally funded research was underutilized); Rebecca S. Eisenberg, *Technology Transfer and the Genome Project: Problems with Patenting Research Tools*, 5 RISK 163, 163 (1994); Frischmann, *Innovation and Institutions*, *supra* note 2, at 406.

[39] *But see* Kieff, *Property Rights and Property Rules*, *supra* note 2 (arguing that the primary role of patents is to facilitate commercialization).

inventions provides the necessary incentive for private investment in creating the inventions in the first place—call this the *reward (or incentive) theory*.[40] Information resources face the well-known supply-side problem, common to public goods: the inability to (cheaply) exclude competitors and nonpaying consumers (free-riders) presents a risk to investors perceived *ex ante* (prior to production of the good), which *may* lead to undersupply.[41] Essentially, in the absence of patent law, there would be a significant underinvestment in invention because of the risk that competitors would appropriate the value of the invention. Granting inventors patents lessens the costs of exclusion, raises the costs of free-riding, encourages licensing, and, as a result, makes a greater portion of the surplus generated by the invention appropriable by the inventor.

In the university research context, patents have these same effects, but where research is funded by government, the economic justification is quite different.[42] Simply put, awarding patents for government funded research is premised on the notion that patents are necessary to facilitate post-patent research, development and commercialization—call this the *commercialization (or prospect) theory*.[43] That is, in the absence of patents, government funded research results would languish underutilized (underdeveloped and undercommercialized) because (1) the researchers and their host institutions lacked the incentives and/or capacity to further develop and commercialize the research or to transfer the research results to industry, and (2) even if transfer was feasible, industry lacked sufficient incentives to invest in development and commercialization without the exclusivity made available by patents in the form of exclusive licenses. Elsewhere I have questioned the strength of these arguments and argued that the classes of research results for which these arguments justify patents may be quite limited.[44]

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[40] *See, e.g.,* MERGES ET AL., INTELLECTUAL PROPERTY IN THE NEW TECHNOLOGICAL AGE 119 (3d. ed. 2003); Mark A. Lemley, *Property, Intellectual Property, and Free Riding*, 83 TEX. L. REV. 1031, 1031 (2005).

[41] For a certain subset of patentable subject matter, trade secrecy or other mechanisms may provide sufficient means for appropriating surplus to attract private investment into production. For this subset, patents may be justified for a variety of reasons associated with disclosure. *See* Strandburg, *What Does the Public Get*, *supra* note 29.

[42] I am concerned in this paper with government funded research. Of course, a significant amount of university research is funded through other means. *See also* Peter D. Blumberg, *From "Publish or Perish" to "Profit or Perish": Revenues from University Technology Transfer and the S 501(c)(3) Tax Exemption*, 145 U. PA. L. REV. 89, 99-100 (1996) (Blumberg details how income from university research and technology transfer would be affected if a corporate tax rate were imposed on universities for their work with private actors).

[43] While the prospect and commercialization theories of patent law are technically distinct and have slightly different foci, they share the same theoretical and practical orientation. *See* Edmund W. Kitch, *The Nature and Function of the Patent System*, 20 J.L. & ECON. 265, 276 (1977) (prospect theory); Kieff, *Property Rights and Property Rules*, *supra* note 2 (commercialization theory); Shubha Ghosh, *Patents and the Regulatory State: Rethinking the Patent Bargain Metaphor After Eldred*, 19 BERKELEY TECH. L.J. 1315, 1353-57 (2004) (noting that prospect and commercialization theories derive from the theoretical work of Demsetz); *see also* Frischmann & Lemley, *Spillovers*, *supra* note 6 (critiquing the Demsetzian approach to intellectual property).

[44] *See* Frischmann, *Innovation and Institutions*, *supra* note 2.

Rather than rehash the arguments and counterarguments, which as noted in the introduction are the subject of continued debate, let me instead assume for purposes of argument that the federal policy of allowing federally funded researchers to patent the research results is warranted. After all, as also noted earlier, the law only encourages and enables, but does not require, university patenting and participation in commercialization.

Most analyses of the role of patents in the university research context focus on the exclusivity of patents: that is, *the benefits of exclusivity*—increased appropriation of surplus; increased technology transfer, licensing and related transactions; increased commercialization; and so on; and *the costs of exclusivity*—deadweight losses, increased transaction costs, patent thickets, and so on. It is important to keep in mind that the benefits and costs of exclusivity are felt differently by different constituencies within a university and thus may lead to internal conflicts.

Exclusivity is a supply-side concern that is relevant to assessing how well markets will function.[45] Patents improve exclusion and consequently the supply-side functioning of markets for university research results as well as those markets further downstream for derivative commercial end-products. Both the reward and commercialization theories of patent law take patent-enabled exclusivity as the relevant *means* for fixing a supply-side problem—essentially, the undersupply of private investment in the production of patentable subject matter or in the development and commercialization of patentable subject matter that would occur in the absence of patent-enabled exclusivity. The theories differ largely in terms of where in the supply chain patent-enabled exclusivity is needed and of the degree of control/exclusivity needed to attract investment.

Patent theories take as a given that the market mechanism will best aggregate information regarding demand for such investment. Put in a slightly different way, the theories are premised on the notion that private investment into the production, development and commercialization of patentable subject matter will be allocated efficiently on the basis of expected returns in downstream commercial markets, so long as patents are available to provide the necessary

[45] Excludability is relevant to a supply-side analysis of whether markets will work efficiently. (Low cost) exclusion is one key to a well-functioning market. If one can (cheaply) exclude others from consuming a resource, one can demand payment as a condition for access. If one cannot (cheaply) exclude others from consuming a resource, then the market may fail to satisfy consumer demand for the resource (undersupply) because suppliers will not be able to recoup their costs from consumers. Simply put, a producer of a good needs must exclude you from consuming the good it has produced if it wishes to charge you for access and consumption. Further, a producer of a good needs to be able to charge you for access if it wishes to recover its costs. If the costs of exclusion are high, then producers must either sink these additional costs and charge higher fees, or run the risk that consumers will "free ride" (i.e., consume the good without paying). Either route may lead to market failure. Thus, if market provision of a resource is desirable but the costs of exclusion are too high, then government intervention to "fix" the market may be appropriate.

exclusivity.[46] This certainly makes good sense, so long as we are talking about private profit-driven investment. But what if investment is not entirely private?

What if demand for research-related outputs and the allocation of infrastructural capital to the production of such outputs is not determined accurately by the market mechanism on the basis of expected returns in downstream commercial markets? What if demand is assessed more efficiently by non-market processes—involving government, non-profits, or community organizations, for example?[47] What if we are talking about public or community investment rather than private investment?

As noted above, university science and technology research systems produce a mix of outputs, some of which may have commercial application, many of which do not. How, if at all, does the availability of patents in the university research context affect demand for university science and technology research system resources?

In *An Economic Theory of Infrastructure and Commons Management*, I explain the concept of demand manifestation, which basically concerns how well consumer demand for infrastructure-dependent outputs translates into demand for infrastructure in the upstream market. Markets may under-represent social demand for infrastructure where output producers fail to observe or appropriate value in output markets. Put another way, the market mechanism exhibits a predictable bias in favor of outputs that generate observable and appropriable benefits; to the extent that infrastructure access or infrastructure capital is scarce, relying on the market mechanism to indicate demand for access or capital may lead to undersupply of socially desired outputs—specifically, public goods and non-market goods that yield positive externalities.[48]

In the past, universities had not directed their resources toward the production of commercial outputs for a variety of reasons—public interest missions, an explicit focus on education of citizenry, the "ivory tower" metaphor

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[46] *See* Jack E. Kerrigan & Christopher J. Brasco, *The Technology Transfer Revolution: Legislative History and Future Proposals*, 31 PUB. CONT. L. J. 277, 281-82 (2002) (The Stevenson-Wydler Act led to the development of the Cooperative Research and Development Agreement, ("CRADA"), which authorized collaborative agreements between federal laboratories and universities. CRADA also led to the Federal Technology Transfer Act of 1986, whereby government scientists and private industry could benefit from entering into CRADAs).

[47] *See* Frischmann, *Economic Theory of Infrastructure*, *supra* note 16; Strandburg, *Curiosity Driven Research*, *supra* note 26;Yochai Benkler, *Coase's Penguin, or, Linux and the Nature of the Firm*,112 YALE L.J. 369 (2002) (comparing market, state, and commons based production as information processing systems).

[48] *See* Frischmann, *Economic Theory of Infrastructure*, *supra* note 16 (explaining this dynamic); *see also* Rebecca Eisenberg, *Patents and Progress of Science: Exclusive Rights and Experimental Use*, 56 U. CHI. L. REV. 1017, 1033 (1989) (discussing a study by Edwin Mansfield which found that private rates of return were almost half that of the social rates of return such that in hindsight, private firms would not have invested in research and development of the innovation despite the social benefits that were ultimately realized).

and the ideal of insulation from market or government influence, and so on. Another important reason is that universities had not always been able to appropriate the benefits of commercially viable research in the absence of patent protection.

Arguably, the obstacles that patents were introduced to overcome—insufficient incentives and capacity to develop and commercialize research results—may have acted as an important buffer between the university science and technology research system and the marketplace. This is not to say that universities and industry did not interact. To the contrary, as David Mowery demonstrates, universities and industry have a long history of interactions.[49] Clearly, the buffer has been permeable over time, but (arguably) it may have been sufficient to insulate system management and resource allocation decisions from the demands of downstream commercial markets.

Although universities were vertically integrated in the sense that they produced both the infrastructure and the outputs, the infrastructure remained generic and the outputs remained mixed because the appropriability of surplus downstream was not a driving factor in the allocation of infrastructural capital. Introducing patents into the system, along with a host of other initiatives aimed at tightening the relationship between universities and industry, may change the dynamic in a relatively predictable manner.

Demand for university-produced commercial research manifests in market-driven transactions made possible by patents (*e.g.,* licenses) and critically, through other university-industry relationships, such an industry sponsorship of research.[50] This creates a demand-pull that, at the margins, may lead to the creeping optimization of the infrastructure.[51] In a realm of limited, scarce resources and robust competition for prestige, students, and funding, university

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[49] Mowery shows that the trend of increased patenting behavior by universities occurred prior to 1980 and the passage of Bayh-Dole. He also suggests that while the relationship between universities and industry may have evolved (been transformed) in the past few decades, transformation should not be attributed to the Bayh-Dole Act itself. *See* David Mowery, *The Bayh-Dole Act and High-Technology Entrepreneurship in U.S. Universities: Chicken, Egg, or Something Else?*, *in* 16 UNIVERSITY ENTREPRENEURSHIP AND TECHNOLOGY TRANSFER: PROCESS, DESIGN, AND INTELLECTUAL PROPERTY, ELSEVIER SCIENCE/JAI PRESS SERIES: ADVANCES IN THE STUDY OF ENTREPRENEURSHIP, INNOVATION, AND ECONOMIC GROWTH (2005).

[50] *See* Strandburg, *Curiosity Driven Research*, *supra* note 26(discussing industry sponsorship of research and noting this effect); Michael S. Mireles, *An Examination of Patents, Licensing, Research Tools, and the Tragedy of the Anti-Commons in Biotechnology Innovation*, 38 U. MICH. J.L. REFORM 141, 144-45 (2004) (same); *see also* Reichman & Uhlir, *A Contractually Reconstructed Research Commons, supra* note 2, at 341-43 (noting that commercial exploitation of university research may pressure universities to "hoard" and protect information).

[51] This is similar to the current debate over the end-to-end architecture of the Internet, although the optimization question is much more explicit and immediate in that context. Frischmann, *Economic Theory of Infrastructure*, *supra* note 16, at Pt. IV.

decisions[52] about how to allocate upstream infrastructure capital to downstream production may be biased toward output markets that generate appropriable returns at the expense of those that generate positive externalities.[53]

As I argue at greater length elsewhere,[54] the market mechanism exhibits a bias for outputs that generate observable and appropriable benefits at the expense of outputs that generate positive externalities. This is not surprising because the whole point of relying on exclusivity—whether provided by traditional property rights or patents—is to enable private appropriation and discourage externalities. The problem with relying on the market mechanism is that potential positive externalities may remain unrealized if they cannot be easily valued and appropriated by those that produce them, even though society as a whole may be better off if those potential externalities were actually produced.[55]

The market mechanism exhibits other biases as well. For instance, because private discount rates tend to be higher than social discount rates, markets tend to be biased toward the short term. Among other things, the divergence between private and social discount rates can lead to overinvestment in applied research and commensurate underinvestment in basic research.[56] Further, incumbent market actors may act strategically to preserve their market positions or to control the direction of innovation.[57] These two biases introduce further

[52] A critical question to consider is who allocates these resources. Kathy Strandburg focuses on the preferences of basic researchers and the differences between homo economicus and homo scientificus. *See* Strandburg, *Curiosity Driven Research*, *supra* note 26. I wonder (1) whether basic researchers are making allocation decisions (I think, no), and (2) whether it is a question of nature vs. nurture – will scientists evolve? Will changes in the environment lead to slow subtle changes in the species? These are difficult questions that require further study.

[53] An empirical study of the allocation of infrastructure capital resources of the types identified above is needed. The datasets that would useful include, among other things, time spent by faculty and graduate students on different types of projects; factors in hiring, promotion and tenure of faculty; and allocation of physical capital such as labs and equipment to general purpose or dedicated commercial projects.

[54] Frischmann, *Economic Theory of Infrastructure*, *supra* note 16.

[55] *See id.*; *see also* Frischmann & Lemley, *Spillovers*, *supra* note 6 (explaining the benefits of letting the spillovers flow).

[56] This bias influences decisions about many infrastructure resources. *Id.* As a general matter, it may lead to underinvestment in the maintenance and repair of existing infrastructure. Similarly, it can lead to overconsumption of environmental resources in the present without due regard to the costs for future generations, or to technological optimization of the Internet in favor of existing or reasonably foreseeable applications to the potential detriment of yet-to-be-developed applications. *Id.*

[57] *See, e.g.*, Arti Rai & Rebecca Eisenberg, *Bayh-Dole Reform and the Progress of Biomedicine,* 66 LAW & CONTEMP. PROBS. 289, 296 (2003) (Noting that upstream patent may stunt subsequent research if the patent covers even basic research that would have enabled more development); Reichman & Uhlir, *supra* note 2, at 342 (In seeking opportunities in commercially marketable research results, universities may "commercialize upstream aggregates of data as research tools and products."); Phillip Pardey, Bonwoo Koo, Carol Nottenburg, *Creating, Protecting, and Using Crop Biotechnologies Worldwide in an Era of Intellectual Property*, 6 MINN. J.L. SCI. & TECH. 213, 225 (2004) (A shift in emphasis may occur away from basic research to applied research as

dynamic complications associated with path dependence and the costs of changing directions once a path has been taken.

As noted previously, university science and technology research systems are inputs into the production of a wide variety of research-related outputs that are used externally and internally to produce value downstream (which may actually involve internal cycling for continued use in the university science and technology research system). There is a real risk that the biases of the market mechanism will "work their way upstream" and infect/affect university science and technology research systems. The most obvious manner in which this dynamic can be expected to operate is simply by way of upstream resource allocation—in a world of scarce resources (particularly, physical, human, and financial capital), it should not be surprising to see an emerging preference for self-supportive activities that yield appropriable benefits that are fed back into the system. As Reichman and Uhlir conclude, "under Bayh-Dole, universities have moved away from policies that favor pure research, both for its own sake and as a tool for advancing higher education. As the costs of education skyrocket, and government funding fails to keep up in many areas, universities have aggressively sought to exploit commercial applications of research results, with an eye toward maximizing returns on investment."[58]

Thus, introducing patents into the university research context is not solely about introducing exclusivity (with its benefits and costs) to fix a supply-side problem—underutilization, underdevelopment, and undercommercialization of research results. Introducing patents into the university research context is also, if not primarily, about manifesting market-driven demand for university-produced research and more subtly for the infrastructural capital aggregated within university science and technology research systems.

This should not be surprising. As it has become clearer that innovation is the engine driving the economy, we should expect pressure to optimize various institutions to support innovation policy.[59] Should universities be optimized to supply innovation? I think not, at least not as a matter of general public policy.[60]

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universities look for more financially rewarding research); *see also* David C. Hoffman, *A Modest Proposal: Toward Improved Access to Biotechnology Research Tools by Implementing a Broad Experimental Use Exception*. 89 CORNELL L. REV. 993, 1025 (2004) ("As the biotechnology industry has diversified and become economically viable, the financial incentive provided by patents has motivated many academic scientists to shift their emphasis from basic to applied research.").

[58] Reichman & Uhlir, *supra* note 52 at 341.

[59] In fact, innovation theory drives similar optimization debates in other infrastructure industries. Frischmann, *Economic Theory of Infrastructure*, *supra* note 16, at Pt. IV (similar pressure to optimize the Internet infrastructure).

[60] Even if universities should be optimized to supply innovation, what exactly does that mean? How would such an objective be accomplished? Assuming that promoting innovation were our sole policy objective, it is not clear what the optimal role of universities would be. The current trend reflects one of many possibilities. Specifically, the current trend envisions universities as

As a general matter, I agree with Richard Florida's argument that an inordinate focus on innovation "misses the larger economic picture."

> Universities have been naively viewed as "engines" of innovation that pump out new ideas that can be translated into commercial innovations and regional growth. This has led to overly mechanistic national and regional policies that seek to commercialize those ideas and transfer them to the private sector. Although there is nothing wrong with policies that encourage joint research, this view misses the larger economic picture: *Universities are far more important as the nation's primary source of knowledge creation and talent. Smart people are the most critical resource to any economy, and especially to the rapidly growing knowledge-based economy on which the U.S. future rests*.[61]

IV. STRATEGIES FOR UNIVERSITIES

Some seem to believe that university commercialization is simply inevitable. In *Capitalizing Knowledge*, for example, Henry Etzkowitz claims that the "function of the university" has "irrevocably changed," that "[t]here is likely no return to an earlier era," and that "the university is changing its organization and ideology to accommodate its new role in economic development." Not only do I disagree, but I find such assertions somewhat hyperbolic and misleading.[62]

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active participants in the post-patent commercialization process, and critically, in the part of the process that bridges the gap between invention and innovation. Bridging this gap is critical to the commercialization process and, as Auerswald and Branscomb have argued, a bridge may be collectively built by university researchers, entrepreneurs, venture capitalists, and other interested parties in a sort of collective entrepreneurship. *See* Philip E. Auerswald & Lewis M. Branscomb, *Start-ups and Spin-offs: Collective Entrepreneurship Between Invention and Innovation*, *in* THE EMERGENCE OF ENTREPRENEURSHIP POLICY 61, 79-80 (Ed., David M. Hart 2003). Of course, building bridges consumes resources. Perhaps universities would better serve innovation policy by focusing further upstream on the wide variety of inputs necessary for innovation, including both intellectual and human capital.

[61] Richard Florida, *The Role of the University: Leveraging Talent, Not Technology*, Science and Technology Online (Summer 1999), at http://www.isues.org/issues/15.4/florida.htm.

[62] Similarly, in *Entrepreneurial Science: The Second Academic Revolution*, Henry Etzkowitz and Andrew Webster claim that "universities are undergoing a 'second revolution.'" Henry Etzkowitz & Andrew Webster, *Entrepreneurial Science: The Second Academic Revolution*, *in* CAPITALIZING KNOWLEDGE: NEW INTERSECTIONS OF INDUSTRY AND ACADEMIA (Etzkowitz et al 1998). I suppose I might be willing to agree if I also were willing to conclude that the broader commercialization, privatization and deregulation movement were part of an inevitable revolution as well. But I do not. Universities (and society more generally) should seriously evaluate such developments (and attendant claims of inevitable revolution) and not succumb to the dominant economic mindset without question. *See* Jennifer Croissant & Sal Restivo, DEGREES OF COMPROMISE: INDUSTRIAL INTEREST AND ACADEMIC VALUES xi-xii (2001) ("From the early 1980s through the present, commercialization of research has been a consensus policy: Not a natural "evolution" of research and development practices, but a conscious reprioritization by a broad coalition of actors.").

Universities, like any other organization, must adapt and evolve with changing economic and social conditions, but each university must determine its own "ideology" and mission and decide on the extent to which it should participate in commercialization, entrepreneurship and economic development.

As noted earlier, the U.S. government has made an explicit policy decision to allow funded entities to obtain patents and thereby has encouraged participation in the commercialization of federally funded research. Nonetheless, universities still must decide on the extent to which they wish to participate in the commercialization process. As a general matter, universities are not required by law to create technology transfer offices, delay or withhold publication of research results, patent research results, issue exclusive licenses, or be entrepreneurs. The Bayh-Dole Act enables universities to participate in the commercialization process, but it does not obligate or constrain them to pursue any particular strategy with respect to federally funded research. Universities remain in the driver's seat and may decide which road to take and at what speed.

There is no uniform answer for universities to the commercialization question. The extent to which universities should actively participate in patenting and commercializing research and to which a university research system should be directed toward patentable research outputs will vary considerably across universities. Some universities may have sufficient resources to resist pressure to optimize the university science and technology research system for commercial outputs; other universities may not. Some universities may in fact prefer to optimize, perhaps because of a particular university mission, a vision of the university role in the modern economy, or strategic reasons related to faculty recruitment, student recruitment, prestige, or public image. In the end, with respect to patent policy, technology transfer, commercialization, and entrepreneurship, universities have choices and face competing incentives. How to proceed depends upon the particular university's objectives for its science and technology research system.

Perhaps idealistically (or even ideologically), I envision robust competition among universities operating on different models and pursuing different strategies, missions, and ideologies. Some universities may actively engage in the commercialization process without affecting their science and technology research systems. Other universities may need to choose whether to optimize their science and technology research systems for commercial research outputs or to sustain a mixed system. In the various markets that universities compete (for faculty, students, government funds, etc.), different strategies may be successful. That is, it may be the case that faculty, students, or funding agencies may look (dis)favorably on optimization. I cannot offer broad prescriptions for universities regarding what strategy to pursue, but I believe it is critical that each university carefully evaluate its strategy in light of the demand-side considerations I have noted in this essay.

Those universities that wish to preserve the integrity of their research systems and resist the pressure to optimize need to affirmatively take steps to manage conflicts of interests, to insulate from the demands of the marketplace upstream decisions regarding infrastructural capital allocation (*i.e.,* decisions that impact the allocation of the five types of aggregated capital resources to particular types of productive activities), and ultimately to minimize (or eliminate) dependence upon commercial revenues for sustaining the research system.[63] Those universities that wish to optimize their research systems for commercial outputs should do so explicitly with a full awareness of the risks and rewards.

V. Conclusion

The issues surrounding commercialization of university research systems are quite similar to those surrounding the commercialization of mixed infrastructure, such as the Internet. These resources are similar in terms of the manner in which they generate social value and in terms of the significant pressures they face to evolve to serve commercial ends. In some cases, such as the Internet, technological design creates a buffer that resists optimization and protects the generic nature of the infrastructure. In other cases, the law may create a similar buffer.[64] In the case of university research systems, traditional buffers between universities and the market seem to be eroding. In this essay, I have argued that this ought to be of significant concern to universities and society more generally because it may lead to a creeping systemic optimization of university research systems for commercializable outputs—a slow and subtle shift in the allocation of infrastructure resources, priorities, relationships, norms, and so on—dictated by the demands of downstream commercial markets. I have not argued that commercialization of research results is inherently bad or undesirable. To the contrary, such commercialization ought to be pursued when possible. It is the commercialization of university science and technology research systems with which I am concerned. Nor have I argued that universities should not participate in commercialization. To the contrary, I suggest some should.

Universities face difficult questions about the degree to which and manner in which they participate in patenting and more generally in the commercialization process. As I noted in the beginning to grapple with these questions, universities must step back from their immediate context, compare their situation with that of other industrial and social contexts, reflect on their role in society, and proceed carefully.

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[63] As Kathy Strandburg notes, many of the concerns in this context stem from scarce public funding. *See* Strandburg, *Curiosity Driven Research*, *supra* note 26.

[64] For an argument that the *Sony* rule, which precludes secondary liability in situations where a technology is "capable of substantial noninfringing uses," properly limits the scope of copyrights and acts as a legal buffer against commercialization, see Brett M. Frischmann, *Peer-to-Peer Technology as Infrastructure: An Economic Argument For Retaining Sony's Safe Harbor For Technologies Capable of Substantial Noninfringing Uses*, 52 J. COPYRIGHT SOCIETY 329 (2005).

This essay has introduced the concept of "patent pull" to capture the demand manifesting quality of patents. Patents "pull" (private and public) investment to productive activities that would be less attractive in the absence of patents. Exploring the role of patents from the demand side reveals that beyond affecting traditional capital investment decisions, patents can have more subtle and perhaps pervasive impacts on organizations and institutions, including but not limited to universities. This essay has focused on university research systems; further research into the role of patents in other systems where government and other non-market processes fare well in manifesting and processing societal demand is needed. That patents are introduced into the "normal" market setting to create distortions is well understood, but the impacts of such distortions upon priorities and the allocation of infrastructural capital within organizations and institutions requires further study.

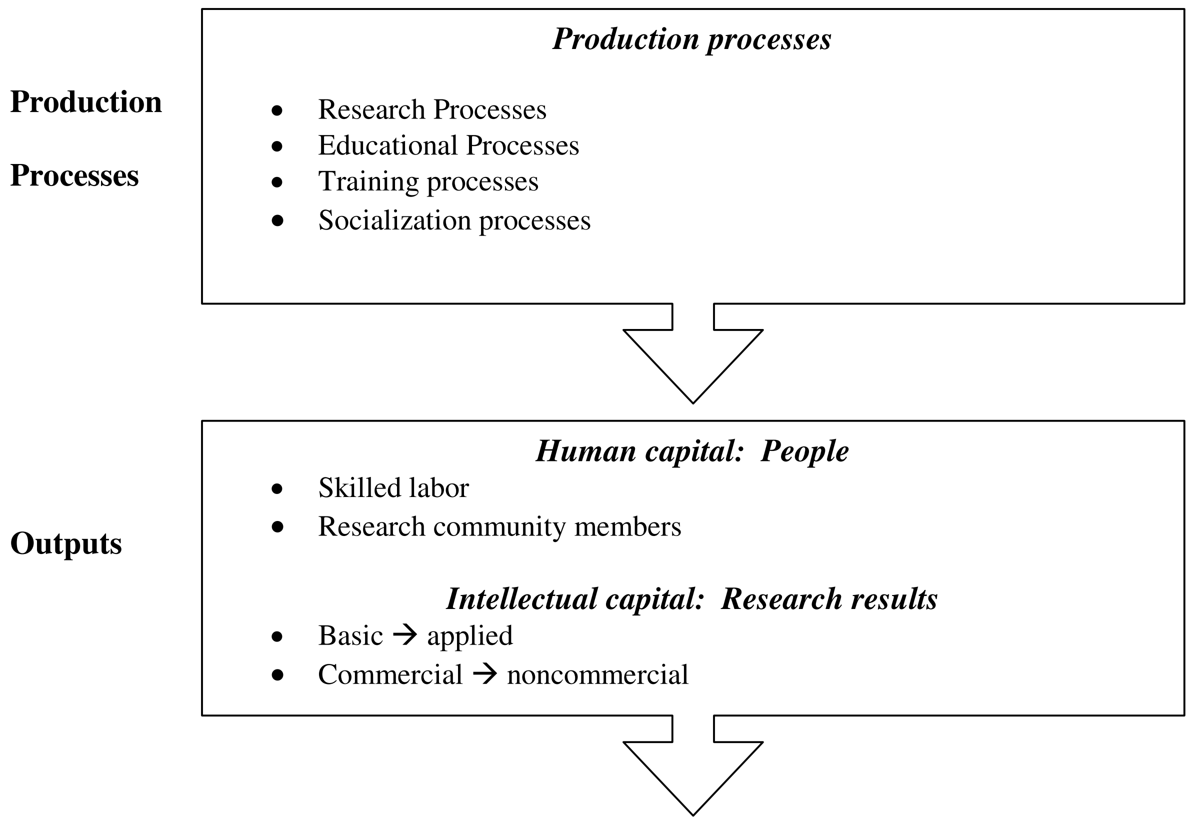

FIGURE ONE:

SIMPLE VIEW OF UNIVERSITY SCIENCE AND TECHNOLOGY RESEARCH SYSTEM AND ITS OUTPUTS

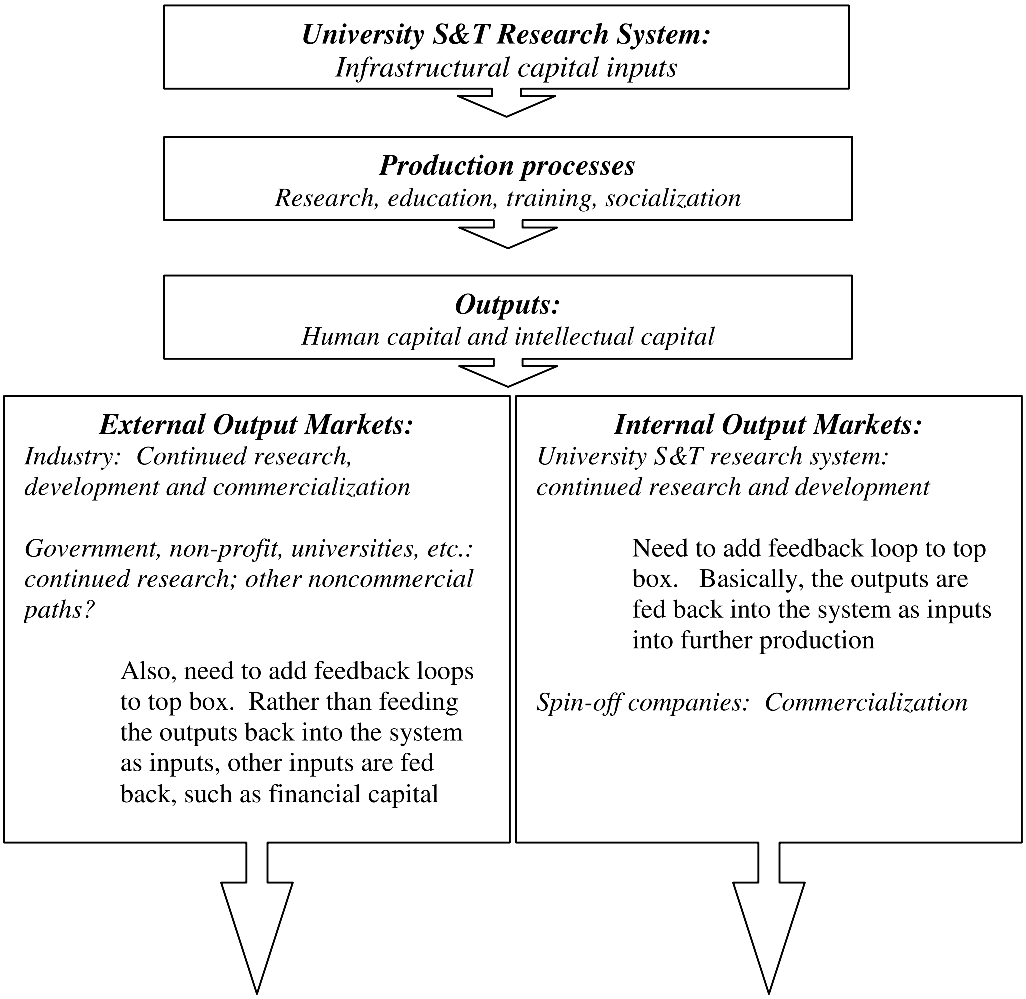

FIGURE TWO:

SIMPLE VIEW OF UNIVERSITY SCIENCE AND TECHNOLOGY RESEARCH SYSTEM, ITS OUTPUTS, AND THE DOWNSTREAM MARKETS FOR OUTPUTS