NOTES

THE NANOTECHNOLOGY PATENT THICKET AND THE PATH TO COMMERCIALIZATION

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ABSTRACT

If even a portion of the rumors surrounding nanotechnology are true, the products and processes brought to market will have the ability to change and advance numerous industries well beyond their current levels. As developers in nanotechnology continue to innovate, they are patenting their discoveries at an ever increasing rate. Nanotechnology represents a new challenge for patent law, and these early patents, if not monitored closely, could effectively lead nanotechnology to a frozen state of development and commercialization before society has had a chance to reap the benefits of this new technology in the form of commercial products and medicinal advances. This Note explores the intellectual property issues surrounding nanotechnology and the societal repercussions of, and possible responses to, the extensive early patenting in this area.

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I. INTRODUCTION

Nanotechnology is expected to "profoundly change our economy, to improve our standard of living, and to bring about the next industrial revolution"[1] or, at least, that is what the government, its committees, and numerous scientists believe. But in order to reach such lofty goals, the entire industry must ensure that the commercialization of nanotechnology products is not stalled by the current patent laws and policies in the United States. This Note examines some of the economic theory behind the

1. NAT'L SCI. & TECH. COUNCIL, COMM. ON TECH., SUBCOMM. ON NANOSCALE SCI., ENG'G, & TECH., NATIONAL NANOTECHNOLOGY INITIATIVE: RESEARCH AND DEVELOPMENT SUPPORTING THE NEXT INDUSTRIAL REVOLUTION, SUPPLEMENT TO THE PRESIDENT'S FY 2004 BUDGET 1 (2003), *available at* http://www.nano.gov/sites/default/files/pub_resource/nni04_budget_supplement.pdf.

enlarging state of patents covering nanotechnology and determines that if tangled patent litigation emerges as the result of the heavy patenting in nanotechnology, courts will be needed to scale back patent protection, and the government may need to step in to ensure a viable path to commercialization.

Nanotechnology is "the understanding and control of matter . . . at dimensions of between approximately 1 to 100 nanometers, where unique phenomena enable novel applications."[2] This new area of science has caught fire over the past decade or so, with the U.S. government providing large sums of money for research and development. This influx of money, together with the hype that nanotechnology will revolutionize multiple industries, has led to numerous patents being issued. But there are characteristics unique to nanotechnology patents and their inventors that set the nanotechnology patent landscape apart from previous technologies. These characteristics and the ever growing number of patents has led to a patent thicket of segmented and overlapping patent rights that will be difficult to navigate for companies wishing to commercialize nanotechnology. Part II of this Note discusses nanotechnology in general, offering a brief primer on the subject. It also describes in detail the characteristics of nanotechnology that have led to the patent issues this field of technology now faces.

Patent law is one of the areas of intellectual property law in which the grant of a limited monopoly is used to stimulate innovation. This usually confers strong rights to a patentee to enforce the full scope of the claims of a patent. Patent law, however, also places the judiciary in a position to interpret patent claims and determine their scope. As such, a historical review shows that the judiciary has in fact construed patent rights differently in different technologies. Part III of this Note delves into the economic theory behind the strength of patent rights and patent scope. In doing so, Part III determines that the current patent landscape of nanotechnology should be afforded somewhat weaker patent protection than could be provided because doing so would clear the way for commercialization without stifling innovation.

Typically, coordination among industry players is necessary to move through a patent thicket. Cross licensing is appropriate when companies are on equal footing with each other and have complementary licenses to offer each other. Similarly, patent pools offer a solution where segmented patent

2. *What It Is and How It Works*, NAT'L NANOTECHNOLOGY INITIATIVE, http://www.nano.gov/nanotech-101/what (last visited July 31, 2011).

rights at different levels of an industry can be consolidated to allow all patents covering a particular product to be licensed to different nanotechnology product manufacturers. But like cross licensing, patent pools require coordination among industry players, and could raise antitrust concerns. The varying characteristics of the nanotechnology business industry place many companies in unequal bargaining positions, making coordination difficult and costly for many. Thus, common solutions to patent thickets, such as cross licenses and patent pools, may not be effective. While discussing these problems in detail, Part IV reviews many other possible solutions suggested by commentators that may help clear the patent thicket. Part IV also reviews the possibility of the government stepping in, as it has with past technologies, to help ensure the commercialization of nanotechnology. Part V summarizes and concludes.

II. NANOTECHNOLOGY OVERVIEW

A. NANOTECHNOLOGY PRIMER

At its simplest, nanotechnology is the study and design of materials or devices that are on the order of one billionth of a meter (10^{-9} m).[3] To put that in perspective, a billionth of a meter is roughly 1/80,000 the diameter of a single strand of human hair, while ten atoms are roughly one nanometer.[4] The idea is that scientists will be able to build materials with properties far superior to those naturally occurring by manipulating atoms, either from a "top-down" or "bottoms-up" approach.[5] The enhanced properties result from taking advantage of the materials' changed behavior at the atomic level.[6] While this broad description does not help one to imagine anything tangible coming from nanotechnology, as the science progresses, the breakthroughs will lead to advances in numerous industries

3. JOHN C. MILLER ET AL., THE HANDBOOK OF NANOTECHNOLOGY: BUSINESS, POLICY, AND INTELLECTUAL PROPERTY LAW 13 (2005).

4. Robert C. Shaddox, *The Big Picture: Nanotechnology Impacts Everyone*, *in* LICENSING BEST PRACTICES: STRATEGIC, TERRITORIAL, AND TECHNOLOGY ISSUES 163, 164 (Robert Goldscheider & Alan H. Gordon eds., 2006); R. Scott Roe, *Nanotechnology: When Making Something Smaller is Nonobvious*, 12 B.U. J. SCI. & TECH. L. 127, 128 (2006).

5. A "top-down" approach refers to using a lithography technique to create a mask, and then using the mask to carve out nanomaterials from a bulk material. A "bottoms-up" approach refers to using specialized tools to physically arrange atoms and molecules into desired positions. MILLER ET AL., *supra* note 3, at 15–17. *See also* G. Nagesh Rao, Note, *Nanotechnology: A Look into the Future of Arising Legal Dilemmas*, 17 ALB. L.J. SCI. & TECH. 835, 838–40 (2007).

6. *See, e.g.*, MARK RATNER & DANIEL RATNER, NANOTECHNOLOGY: A GENTLE INTRODUCTION TO THE NEXT BIG IDEA 7, 56–57 (2003) (describing properties of nanoscale circuits and the increased strength of carbon nanotubes).

including electronics, healthcare, energy, and consumer products.[7]

In the present, the production of inorganic building-block-type nanomaterials, such as fullerenes,[8] carbon nanotubes,[9] nanowires,[10] and semiconductor nanocrystals,[11] are already underway and being applied in various industries. For example, depending on production parameters, carbon nanotubes are capable of carrying a thousand times more current density than traditional copper wire.[12] This will allow for smaller electronics packages than are currently possible.[13] Additionally, organic nanomaterials, such as DNA, viruses, and polymers, are slowly finding their way to markets. For example, dendrimers, "[o]ne class of polymers,"[14] are being used for drug delivery systems.[15] The Project on Emerging Nanotechnologies inventoried 1317 consumer products or product lines that incorporate nanotechnology in some way.[16] In the near term, nanotechnology will help advances in sensors and measurement, transistors, digital storage, communications, energy, and medicine.[17] In the

7. *E.g.*, DAVID M. BERUBE, NANO-HYPE: THE TRUTH BEHIND THE NANOTECHNOLOGY BUZZ 186 (2006).

8. Buckminsterfullerene was once the full name of fullerene. MILLER ET AL., *supra* note 3, at 17. "Buckeyballs" were a subset of this group that had a soccer-ball-like appearance. *Id.* When they were first discovered, it was predicted that Buckeyballs' unique properties would allow them to be used in everything from consumer products to medical applications. *Id.*

9. "Carbon nanotubes . . . can be thought of as 'rolled-up' layers of interconnected carbon atoms." *Id.* They are made as either "multi-walled nanotubes . . . [that] contain a number of hollow cylinders of carbon atoms," or "single-walled nanotubes . . . [that] consist of a single layer of carbon atoms and a hollow core." *Id.*

10. "Nanowires are solid wires made from silicon, zinc oxide, and various metals" and have diameters on the nanoscale, but they can have "lengths in the tens of micrometers." *Id.* at 18. "Nanowires have unique optical and electrical properties that, like those of nanotubes, emerge primarily from their low dimensionality." *Id.*

11. "Semiconductor nanocrystals . . . , which are sometimes referred to as quantum dots," can be altered in size to "alter the wavelengths of light they . . . emit." *Id.*

12. *See id.* Other such present term applications include the use of nanomaterials as catalysts in reactions ranging from catalytic converters to rocket propellants, as coatings and films, as electron field emitting devices for display technologies, and as composites with increased mechanical properties. *Id.* at 22–23; Shaddox, *supra* note 4, at 167.

13. *See* MILLER ET AL., *supra* note 3, at 18.

14. Dendrimers "are treelike molecules that can be made to function like a variety of biological structures. They have surface properties that allow them to bind to other molecules and can carry molecules internally." *Id.* at 20–21.

15. *Id.*; *About Us*, DENDRITIC NANOTECHNOLOGIES, INC., http://www.dnanotech.com/aboutus.asp (last visited July 31, 2011).

16. *Consumer Products: Analysis*, THE PROJECT ON EMERGING NANOTECHNOLOGIES, http://www.nanotechproject.org/inventories/consumer/analysis_draft/ (last visited July 31, 2011). Readers are encouraged to view the various products on The Project's webpage by starting at http://www.nanotechproject.org/inventories/consumer/.

17. MILLER ET AL., *supra* note 3, at 23–28; Shaddox, *supra* note 4, at 167.

long term, scientists envision nanotechnology giving rise to ultra-lightweight bulletproof armor, solar and hydrogen fuel cells, computers with significantly increased processing power, and cures for cancer and AIDS.[18]

To reach these goals, the U.S. government is completely on board. While it is not easy for the government to appropriate funds for scientific developments, in the case of nanotechnology, two major arguments were advanced. First, "the time to move research to commercialization exceeded the period of time private markets" would be willing to wait.[19] Second, by treating nanotechnology like the next space race, nanotechnology was linked to "national economic competitiveness, employment goals, and national pride."[20] President Clinton launched the National Nanotechnology Initiative ("NNI")[21] in 2000 with $422 million; and government funding continued to grow through the signing of the 21st Century Nanotechnology Research and Development Act[22] in 2003, which committed $3.7 billion to nanotechnology research and development between fiscal years 2005 and 2008.[23] The 2011 budget proposal provides for another $1.8 billion in 2011 alone, bringing total nanotechnology government spending since 2001 to more than $14 billion.[24] The United States is not the only big spender, as "over thirty other countries ha[ve] already initiated their own national nanotechnology programs."[25]

18. *See, e.g.*, MILLER ET AL., *supra* note 3, at 2.

19. *See* BERUBE, *supra* note 7, at 94.

20. *Id.*

21. The NNI "is a U.S. Government research and development (R&D) program of twenty-five agencies working together toward the common challenging vision of '*a future in which the ability to understand and control matter at the nanoscale leads to a revolution in technology and industry that benefits society*.'" NAT'L SCI. & TECH. COUNCIL, COMM. ON TECH., SUBCOMM. ON NANOSCALE SCI., ENG'G, & TECH., NATIONAL NANOTECHNOLOGY INITIATIVE: RESEARCH AND DEVELOPMENT SUPPORTING THE NEXT INDUSTRIAL REVOLUTION, SUPPLEMENT TO THE PRESIDENT'S FY 2011 BUDGET 3 (2010) [hereinafter NNI 2011 BUDGET], *available at* http://www.nano.gov/sites/default/files/pub_resource/nni_2011_budget_supplement.pdf.

22. 21st Century Nanotechnology Research and Development Act, Pub. L. No. 108-153, 117 Stat. 1923 (codified at 15 U.S.C. §§ 7501–7509 (2006)).

23. § 7505, 117 Stat. at 1929; MILLER ET AL., *supra* note 3, at 3.

24. *See* NNI 2011 BUDGET, *supra* note 21, at 7–8. The 2012 budget provides for another $2.1 billion for the NNI, bringing the cumulative spending up to $16.5 billion since 2001. NAT'L SCI. & TECH. COUNCIL, COMM. ON TECH., SUBCOMM. ON NANOSCALE SCI., ENG'G, & TECH., NATIONAL NANOTECHNOLOGY INITIATIVE: RESEARCH AND DEVELOPMENT SUPPORTING THE NEXT INDUSTRIAL REVOLUTION, SUPPLEMENT TO THE PRESIDENT'S FY 2012 BUDGET 7–8 (2011), *available at* http://www.nano.gov/NNI_2012_budget_supplement.pdf.

25. Roe, *supra* note 4, at 129.

B. What Is Special About Nanotechnology Regarding the Patent Laws

Given the amount of money flowing into nanotechnology, not only from the government, but from corporate and private sources as well, nanotechnology has set off what some refer to as a "patent gold rush."[26] Because intellectual property portfolios, and patents in particular, are useful business tools and are essential to securing investments for start-ups, companies and universities researching in all areas of nanotechnology began patenting early and often.[27] Because the nature of patent prosecution generally leads to patent claims that are as broad as are supportable by the patent application's written disclosure, and in part because the United States Patent and Trademark Office ("USPTO") had not even created a prior art classification for nanotechnology prior to 2004, nor is there a special nanotechnology examination group,[28] nanotechnology patents were subject to ineffective review and were being issued regularly, broadly, and with questionable validity.[29] "This patent 'land grab' mentality is also fueled by the relative lack of products and processes in the marketplace which compels companies to demonstrate confidence by generating intellectual property in order to convince venture capitalists to invest," and as a result, it has compelled some companies to "claim as much IP as possible in their patent application out of fear that their competitors will beat them to the punch."[30]

With this patent background, commentators have described a number of reasons why patents in nanotechnology are facing a different intellectual property regime when compared to previous technologies. These unique

26. Raj Bawa, S.R. Bawa & Stephen B. Maebius, *The Nanotechnology Patent 'Gold Rush,'* 10 J. INTELL. PROP. RTS. 426, 427–28 (2005).

27. *See* Raj Bawa, *Nanotechnology Patent Proliferation and the Crisis at the U.S. Patent Office*, 17 ALB. L.J. SCI. & TECH. 699, 719–23 (2007); Mark A. Lemley, *Patenting Nanotechnology*, 58 STAN. L. REV. 601, 602–05 (2005); Ruben Serrato, Kirk Hermann & Christopher Douglass, *The Nanotech Intellectual Property Landscape*, 2 NANOTECHNOLOGY L. & BUS. 150, 152 (2005).

28. *See, e.g.*, Bawa, *supra* note 27, at 706, 724–25; Rao, *supra* note 5, at 856–57.

29. *See, e.g.*, MILLER ET AL., *supra* note 3, at 71–74; Bawa, *supra* note 27, at 721–28; Sean O'Neill et al., *Broad Claiming in Nanotechnology Patents: Is Litigation Inevitable?*, 4 NANOTECHNOLOGY L. & BUS. 29, 30–31 (2007); Rao, *supra* note 5, at 857–58; Serrato, Hermann & Douglas, *supra* note 27, at 152. In 2004, the USPTO created a cross-reference classification for nanotechnology that consolidates prior art patents into various sublcasses, but there still remains no "art unit" of examiners devoted solely to nanotechnology; while this is a step in the right direction, it does not alleviate all problems at the USPTO. *See generally* Blaise Mouttet, *Nanotech and the U.S. Patent & Trademark Office: The Birth of a Patent Class*, 2 NANOTECHNOLOGY L. & BUS. 260 (2005) (describing the USPTO approach to creating the nanotechnology cross-reference classification).

30. O'Neill et al., *supra* note 29, at 31.

characteristics are described in the following sections.

1. Patents Held by Universities

While universities and public-interest foundations typically "hold only about one percent of patents issued . . . each year," in nanotechnology, universities hold at least 12 percent of patents granted each year.[31] And not only are universities holding more patents, the types of patents that they hold will most likely be "upstream"[32] patents that are the building blocks of nanotechnology products yet to come.[33] Indeed, most nanotechnology start-ups that are forming are spin-offs from university research groups that have patented pioneering breakthroughs in their research.[34]

There are a handful of reasons that might explain the increase in patent holdings at universities. Universities are often at the forefront of scientific research, but it could be that only now they "are patenting rather than simply publishing" their findings.[35] The aggressive patenting policies of universities of the modern era may have been brought on by the passage of the Bayh-Dole Act of 1980,[36] which truly ushered in a change in patent policy. Prior to the passage of the act, the federal agency funding the

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31. Lemley, *supra* note 27, at 615–16.

32. In the context of this note, "upstream" refers to patents that cover inventions that are early research inventions that will likely be necessary to practice patents that are considered "downstream," which refers to inventions that are closer to a commercialized product. For examples of some upstream and downstream nanotechnology inventions, see Raj Bawa, *Nanotechnology Patenting in the US*, 1 NANOTECHNOLOGY L. & BUS. 31, 44 (2004).

33. Lemley, *supra* note 27, at 616. Lemley further supports this proposition by noting that seven out of the ten foundational patents he discusses are held by universities and that 60 percent of the publicly announced nanotechnology patent licenses in 2003 were made by universities. *Id.*

34. *See, e.g.*, MILLER ET AL., *supra* note 3, at 36; Behfar Bastani et al., *Technology Transfer in Nanotechnology: Licensing Intellectual Property from Universities to Industry*, 1 NANOTECHNOLOGY L. & BUS. 166, 166 (2004).

35. Lemley, *supra* note 27, at 616–17.

36. Bayh-Dole Act of 1980, Pub. L. No. 96-517, 94 Stat. 3019, § 200–212 (codified as amended at 35 U.S.C. § 200-212 (2006)). The policy and objective of the Bayh-Dole Act is stated as the following:

> It is the policy and objective of the Congress to use the patent system to promote the utilization of inventions arising from federally supported research or development; to encourage maximum participation of small business firms in federally supported research and development efforts; to promote collaboration between commercial concerns and nonprofit organizations, including universities; to ensure that inventions made by nonprofit organizations and small business firms are used in a manner to promote free competition and enterprise without unduly encumbering future research and discovery; to promote the commercialization and public availability of inventions made in the United States by United States industry and labor; to ensure that the Government obtains sufficient rights in federally supported inventions to meet the needs of the Government and protect the public against nonuse or unreasonable use of inventions; and to minimize the costs of administering policies in this area.

Id. § 200.

research project typically retained any patent rights.[37] Patent policy prior to the passage of Bayh-Dole required the government to freely grant nonexclusive licenses to anyone wishing to practice them; exclusive licenses were not even allowed for federally owned patents.[38] Thus, numerous technologies that were federally funded, such as the protocols that gave rise to the Internet, were freely available to those wishing to commercialize them.[39] It seems, however, that this approach was not successful, and Congress passed the Bayh-Dole Act hoping to provide funding to technologies that were being created at research universities that showed commercial promise, giving them an opportunity to be commercialized.[40] The Act was designed to promote technology transfer by allowing businesses, universities, and nonprofit organizations to retain the patent rights of federally funded inventions.[41] This change in patent policy allowed these new patent holders to provide exclusive licenses of promising technologies to private investors and paved the way for private investment.[42]

Another reason for increased patenting by universities could be that while nanotechnology may lend itself particularly well to trade secret protection in the commercial context because it is relatively easy for companies to keep nanotechnologies secret, even after commercialization on the open market, universities have no such incentive to keep inventions and advances a secret.[43] As a result, universities may simply patent their nanotechnology inventions more often than commercial businesses. Lastly, it could be that universities are hoarding more patents because they are no longer protected by an experimental-use defense and are ensuring that infringement suits are not brought against them while they are researching technologies.[44]

37. *See* Ted Sabety, *Nanotechnology Innovation and the Patent Thicket: Which IP Policies Promote Growth?*, 15 ALB. L.J. SCI. & TECH. 477, 484 (2005).

38. *Id.* at 485.

39. *See id.* at 482–83, 486.

40. *See id.* at 486–87.

41. Lemley, *supra* note 27, at 617; Sabety, *supra* note 37, at 487.

42. *See* Sabety, *supra* note 37, at 487. Indeed, *The Economist* reported in 2002 that since the Bayh-Dole Act was enacted, it has contributed $40 billion annually to the U.S. economy. Opinion, *Innovation's Golden Goose*, THE ECONOMIST, Dec. 14–20, 2002, at 3, 3.

43. Lemley, *supra* note 27, at 617. Lemley notes that this third point may have an interesting side effect: "it suggests that the number of nanotechnology patents *understates* the innovation occurring in the field, since much of it is being kept secret." *Id*.

44. *See* Madey v. Duke Univ., 307 F.3d 1351, 1362–64 (Fed. Cir. 2002) (deciding that universities, though not always seeking a commercial end, are serving their own business purpose and cannot stand by the weak protection of the experimental use defense); Nicholas M. Zovko, Comment, *Nanotechnology and the Experimental Use Defense to Patent Infringement*, 37 MCGEORGE L. REV.

2. Foundational Patenting

"This is nearly the first new field in almost a century in which the basic ideas were patented at the outset."[45] In what can be called "'enabling' technologies," such as "computer hardware, software, the Internet, and even biotechnology," the "building blocks" of these patents were either unpatented by mistake or because patents obtained by university and government researchers were either licensed freely by the government, invalidated, or the inventors had no interest in patents.[46] For example, patent protection for software was not even available until 1981,[47] while much early software development had been progressing without such protection.[48] And at the beginning of biotechnology, partly because the Bayh-Dole Act had not yet passed to provide an investment path to commercial exploitation, and partly because policy at the time dictated that matters of public health should be dedicated to the public, universities were not patenting their research.[49]

Even in some industries, when foundational patents did issue, they had no effect on the initial industry growth because the patents were locked up in interference proceedings while the industry was growing.[50] Antitrust policies also helped to ensure that some foundational patents were licensed freely rather than dominated by a single entity.[51] In sum, a review of emergent technologies over the last eighty years or so shows that "invention after invention was put into the public domain, freely licensed because of government or university policy, subjected to inventorship disputes for decades, or otherwise avoided patenting during the formative years of the industry."[52]

129, 131 (2006).

45. Lemley, *supra* note 27, at 606.

46. *Id.*

47. Until the 1981 decision *Diamond v. Diehr*, 450 U.S. 175 (1981), the United States Supreme Court treated software as unpatentable subject matter, considering it merely a mathematical algorithm. *See* Parker v. Flook, 437 U.S. 584, 594–95 (1978); Gottschalk v. Benson, 409 U.S. 63, 71–73 (1972).

48. *See* William Fisher, Intellectual Property and Innovation: Theoretical, Empirical, and Historical Perspectives 23–24 (May 2, 2001), http://cyber.law.harvard.edu/people/tfisher/Innovation.pdf.

49. *See* Sally Smith Hughes, *Making Dollars Out of DNA: The First Major Patent in Biotechnology and Commercialization of Molecular Biology, 1974–1980*, 92 ISIS 541, 546–49 (2001).

50. *See* Lemley, *supra* note 27, at 606–07 (discussing the industries of integrated circuits, polymer chemistry, and the laser).

51. For example, AT&T, which held early patents on the transistor, was forced to license its patents under an antitrust consent decree. *Id.* at 607; Sabety, *supra* note 37, at 490–91. IBM also granted nonexclusive licenses under an antitrust consent decree. Lemley, *supra* note 27, at 607–08.

52. Lemley, *supra* note 27, at 607. *See also id.* at 607–13 (discussing the patent situation at the outset of computers, software and the Internet, biotechnology, integrated circuits, lasers, polymer

By contrast, in today's age, given the importance of patents to securing licensing revenues and venture capital, coupled with a patent policy in the government and universities which favors patent exploitation, as indicated above, nanotechnology patents have been sought early and often. Indeed, some commentators believe that the early foundational patenting is being done so that royalties can be extracted from licenses that will be required to practice these early patents without being sued for infringement.[53] There have been a few industries in the past that also had their foundational inventions patented, which arguably led to some problems.[54] Some of these instances are discussed in the later sections of this Note.

3. Multi-Industry Nature

Nanotechnology has its roots in materials science, but to be put to its broad applications, expertise is necessary in numerous fields such as semiconductor design, biotechnology, telecommunications, and textiles.[55] The key is that the exploitation of materials' properties at the nanoscale can be adapted to these various industries.[56] This means that some inventions will have applications in more than one industry. While some nanotechnology inventions exist within a single industry, the multi-industry nature of many of the inventions will lead to a situation in which patent holders are not participants in every industry to which their invention could be applied.[57]

This situation can have an effect on a patent holder's incentives to license their patent.[58] "Certainly, the experience of the semiconductor, Internet, and information technology industries has been that patentees who do not participate in the market are more likely to sue to enforce their patents than those who are in the market."[59] While past experience is not dispositive of how patent holders will treat their nanotechnology patents, it does indicate that people looking to secure rights will have to look outside their own industry.[60]

chemistry, and television).

53. *See, e.g.*, Bawa, Bawa & Maebius, *supra* note 26, at 428–29.
54. *See, e.g.*, Fisher, *supra* note 48, at 20–21; Lemley, *supra* note 27, at 606 n.23.
55. Lemley, *supra* note 27, at 614; Rao, *supra* note 5, at 839.
56. *See* Lemley, *supra* note 27, at 614.
57. *Id.*
58. *Id.* at 615.
59. *Id.*
60. *Id.*

4. Lack of Standards

One feature of some importance, and could be considered a sub-issue to the multi-industry nature of nanotechnology, is the lack of anticipatory standards and terminology during the early period of nanotechnology.[61] It is arguable that this lack of consistency added to the numerous and broad patents. Because the USPTO still does not have a dedicated examination group for nanotechnology, patent applications that may be covering the same or overlapping subject matter may get routed to different examination groups because of the different terminology used, and ultimately be issued.[62] This could lead to barriers in communications between scientists, complicated litigation when construing claims where terminology is not uniform, as well as act as a barrier to successful commercialization of nanotechnology because of the inability "to consistently characterize the properties and benefits of the basic building blocks that underpin much of the theoretical work."[63]

This problem, however, has not gone unaddressed. The typical standards-setting bodies, such as the American Society For Mechanical Engineers, the National Institute of Standards and Technology, and the Institute of Electrical and Electronics Engineers, have been involved in trying to help build standards for nanotechnology measurement.[64] Furthermore, the American National Standards Institute has created a nanotechnology standards panel and is active in the International Organization for Standardization work on standardization of nanotechnologies across the globe.[65] Additionally, glossaries of nanotechnology terms have come out of the public sector (for example, USPTO)[66] and the private sector (for example, Institute of

61. *See* MILLER ET AL., *supra* note 3, at 262.

62. *See* John C. Miller & Drew L. Harris, *The Carbon Nanotube Patent Landscape*, 3 NANOTECHNOLOGY L. & BUS. 427, 436 (2006) (describing the effects of terminology and subject matter on the patenting of carbon nanotubes); Edward Rashba et al., *Standards in Nanotechnology*, 1 NANOTECHNOLOGY L. & BUS. 185, 191 (2004); Serrato, *supra* note 27, at 152.

63. MILLER ET AL., *supra* note 3, at 262. *Accord* Rashba et al., *supra* note 62, at 191.

64. MILLER ET AL., *supra* note 3, at 262–64.

65. *See Standards Activities Overview*, AM. NAT'L STANDARDS INST., *http://www.ansi.org/standards_activities/overview/overview.aspx?menuid=3* (last visited Aug. 1, 2011); *ANSI Accredited U.S. TAG to ISO/TC 229 Nanotechnologies*, AM. NAT'L STANDARDS INST., http://www.ansi.org/standards_activities/standards_boards_panels/tc229.aspx?menuid=3 (last visited Aug. 1, 2011).

66. *See* U.S. PATENT AND TRADEMARK OFFICE, CLASSIFICATION DEFINITIONS: CLASS 977 NANOTECHNOLOGY 977-6 to 977-10 (2010) [hereinafter CLASS 977 DEFINITIONS], *available at* http://www.uspto.gov/web/patents/classification/uspc977/defs977.pdf. Though far from perfect, most agree that the creation of Classification 977 by the USPTO was an important step to helping examiners,

Nanotechnology).[67] It is difficult to quantify the success of these efforts, but such a move towards standardized terminology can reasonably be assumed to facilitate communication and uniformity. The efforts of the USPTO are especially noteworthy, as these definitions will be used by examiners at the USPTO, regardless of technology sector, and help standardize the language used in future issued patents.[68]

C. Patent Problems for Nanotechnology

The unique features pointed out above, coupled with the effects of the patent gold rush, are expected to cause problems for the nanotechnology industry as it moves from the research phase to the commercialization phase. Issued overbroad patents will lead to "a swirl of damages . . . from lost revenues, resources, time, as well as appeals and infringement suits."[69] In addition to costs associated with overbroad patents, a patent thicket has grown that is not only large in its number of patents, but complex, by virtue of nonstandardized language used in the patents, the broad scope that they cover, and the diverging interests of patent holders from various industries.[70]

Generally, a patent thicket will require an innovator to seek out and negotiate licenses with many patent holders in the field of endeavor to ensure that the innovator will not be sued for patent infringement when building upon the work of others.[71] Not only could the licenses themselves be costly, the transaction costs associated with seeking out these patent holders could also be large.[72] And, as mentioned above, this basic problem is further exacerbated in nanotechnology because rights holders could be

attorneys, and inventors navigate the U.S. nanotechnology patent landscape. *See, e.g.*, O'Neill et al., *supra* note 29, at 31.

67. *See Glossary of Nanotechnology Terms*, INST. OF NANOTECHNOLOGY, http://www.nano.org.uk/nano/glossary.htm (last visited Aug. 1, 2011).

68. *See generally* CLASS 977 DEFINITIONS, *supra* note 66, at 977-6 to 977-10.

69. Rao, *supra* note 5, at 858.

70. *See* Lemley, *supra* note 27, at 618–21 and *supra* text accompanying notes 55–63. For a general discussion of patent thickets, see Carl Shapiro, *Navigating the Patent Thicket: Cross Licenses, Patent Pools, and Standard Setting*, *in* 1 INNOVATION POLICY AND THE ECONOMY 119–22 (Adam B. Jaffe et al. eds., 2001). This is not to suggest that every sector of nanotechnology is plagued by a patent thicket, though many of those relying on earlier patents are. *Compare* Miller & Harris, *supra* note 62, at 449–50 (discussing the impact of the carbon nanotube patent thicket), *with* James W. Beard & Albert P. Halluin, *An Analysis of CIGS Solar Cell Technology*, 6 NANOTECHNOLOGY L. & BUS. 19, 28–29 (2009) (describing the lack of a patent thicket in copper indium gallium selenide ("CIGS") technology, but admitting that it may be too early to tell if a patent thicket will arise).

71. Shapiro, *supra* note 70, at 121.

72. *See id.* at 120, 124.

outside the field of endeavor as well.[73]

Closely related to the patent thicket is the holdup problem, which exists either between horizontally situated firms with complementary patents, or when firms that are downstream from the upstream building block patents create products which inadvertently infringe the upstream patents.[74] The holdup problem can also stifle the commercialization phase when the inadvertently infringed patent's holder comes to demand royalties after the product has become a commercial success.[75]

> The holdup problem is worst in industries where hundreds if not thousands of patents, some already issued, others pending, can potentially read on a given product. In these industries, the danger that a manufacturer will step on a land mine is all too real. The result will be that some companies avoid the mine field altogether, that is, refrain from introducing certain products for fear of holdup. Other companies will lose their corporate legs, that is, will be forced to pay royalties on patents that they could easily have invented around at an earlier stage, had they merely been aware that such a patent either existed or was pending. Of course, ultimately the expected value of these royalties must be reflected in the price of final goods.[76]

Given the discussion thus far, it is not hard to see that the patent landscape of nanotechnology fits within this description, and such a situation will severely hamper the commercialization of nanotechnology.

If these problems are not cured, the industry can expect to be overrun with costly litigation and stifling transaction costs.[77] While patent litigation tools such as Markman hearings and prosecution history estoppel tend to narrow the scope of patents, those that remain broad and overlapping will lead to confusion as to who owns the rights to a particular invention.[78] Confusion regarding which firm owns rights, when multiple may assert that they do, will lead to further increased costs, either through larger litigations, due diligence, or transaction costs.[79] This uncertainty will also

73. *See supra* note 57 and accompanying text.

74. *See* Shapiro, *supra* note 70, at 124–26. *See also* MILLER ET AL., *supra* note 3, at 72 (describing the patent thicket and holdup situation of carbon nanotubes).

75. *See* Robert P. Merges & Richard R. Nelson, *On the Complex Economics of Patent Scope*, 90 COLUM. L. REV. 839, 865–66 (1990); Shapiro, *supra* note 70, at 125.

76. Shapiro, *supra* note 70, at 126.

77. *See* Merges & Nelson, *supra* note 75, at 865–66.

78. *See, e.g.*, O'Neill et al., *supra* note 29, at 33–38 (showing examples of ambiguities in claim construction of nanotechnology patents).

79. *See, e.g.*, Miller & Harris, *supra* note 62, at 449–50 (discussing the effects of the carbon nanotube patent thicket); Serrato, *supra* note 27, at 153–54 (explaining confusion in overlapping foundational carbon nanotube patents).

lead to less venture capital for start-ups trying to secure financing as they try to move products toward commercialization because attracting financing requires a defensible intellectual property portfolio.[80] Indeed, as we move closer to nanotechnology commercialization, large patent litigations are proving too much for some companies to handle, as a few have already filed for bankruptcy.[81]

It is typically suggested that the patent thicket problem can be cured by coordination among the industry players and limiting the scope of patents,[82] and that the holdup problem can be cured by giving industry players better information about forthcoming patents or the ability to challenge the validity of patents.[83] These and other possible solutions to the nanotechnology patent thicket are discussed in detail in Part IV. But first, an analysis of nanotechnology and its intellectual property from an economic perspective follows and seeks to show why strong rights are not desirable, and that it is appropriate to curtail these rights through various types of methods.

III. AN ECONOMIC ANALYSIS OF NANOTECHNOLOGY INTELLECTUAL PROPERTY

At a basic level, the patent system is a way for the government to incentivize technological innovation by providing a limited-time monopoly to the patent holder. Though the patent laws are written uniformly across all technologies and industries, they do not necessarily need to be applied

80. *See* MILLER ET AL., *supra* note 3, at 77.

81. *See, e.g.*, Reed L. Christiansen et al., *IP Disputes and Nanotechnology Company Bankruptcies*, 6 NANOTECHNOLOGY L. & BUS. 374, 374–75 (2009) (describing the bankruptcies of nanotechnology companies Evident Technologies, Inc., Luna Innovations, Inc., and the exit from the U.S. quantum dot market of U.K.-based Nanoco Technologies, all due to the expenses and judgments of litigation). *But see* Sarah Bruyn Jones, *Luna Innovations Emerges from Bankruptcy*, THE ROANOKE TIMES, Jan. 12, 2010, http://www.roanoke.com/news/breaking/wb/232753.

82. *See, e.g.*, Dan L. Burk & Mark A. Lemley, *Policy Levers in Patent Law*, 89 VA. L. REV. 1575, 1627 (2003) (discussing the need for coordination among patent holders); Lemley, *supra* note 27, at 623–27 (discussing businesses' motivation for licensing); Shapiro, *supra* note 70, at 126 (discussing transaction costs among businesses and patent holders).

83. Shapiro, *supra* note 70, at 126. There are also suggestions that the reverse doctrine of equivalents could help solve the holdup problem, but recent case law suggests that the doctrine is not as strong as it once was. S*ee, e.g.*, Tate Access Floors, Inc. v. Interface Architectural Res., Inc., 279 F.3d 1357, 1368 (Fed. Cir. 2002) (determining that the reverse doctrine of equivalents has little or any application after the enactment of 35 U.S.C. § 112); Merges & Nelson, *supra* note 75, at 866; Andrew Wasson, *Protecting the Next Small Thing: Nanotechnology and the Reverse Doctrine of Equivalents*, 2004 DUKE L. & TECH. REV. 10, ¶¶ 12–13. And though the Federal Circuit reaffirmed the doctrine in *Amgen, Inc. v. Hoechst Marion Roussel, Inc.*, 314 F.3d 1313 (Fed. Cir. 2003), it still refused to apply it to the case. *Id*. at 1351.

uniformly to all technologies and industries.[84] Nanotechnology, especially in light of the patent proliferation described in Part II, warrants special treatment from the patent laws as patents are reviewed by the USPTO, the courts, and patent policymakers. The following review of the economics of nanotechnology intellectual property reveals that a strong patent regime may not be appropriate.

A. DETERMINING WHETHER A STRONG OR WEAK INTELLECTUAL PROPERTY REGIME IS APPROPRIATE

One of the complications created by intellectual property rights is that they can "sometimes give rise to socially wasteful duplicative or uncoordinated inventive activity."[85] This happens when firms are working to reach the same invention, either at the pioneering or secondary level, as well as when firms are attempting to design around already patented technologies.[86] These socially wasteful activities have arguably already occurred in nanotechnology to some extent, as evidenced by the number of patents that seem to cover the same inventions as multiple firms raced to patent pioneering inventions.[87] But fixing the problem is not always easy, as "reducing social waste at one stage of the inventive process commonly increases it at another."[88]

1. The Factors

Commentators have looked beyond theoretical arguments for how the patent system should operate and have examined empirical and historical literature. In doing so, one such commentator examined four fields of technology: pharmaceuticals, biotechnology, aviation, and computer software.[89]

84. *See* Burk & Lemley, *supra* note 82, at 1577. *See also infra* Part IV.F (discussing possible judicial interpretations as applied to nanotechnology).

85. Fisher, *supra* note 48, at 8.

86. *Id.*

87. *See, e.g.*, Miller & Harris, *supra* note 62, at 436–37 (noting large numbers of patents related to carbon nanotubes); Blaise Mouttet, *The Patent Landscape for Electron Emitting Nanomaterials*, 4 NANOTECHNOLOGY L. & BUS. 313, 318 (2007) (noting the over 100 patents which include recitation of carbon nanotubes); Serrato, *supra* note 27, at 153–54.

88. Fisher, *supra* note 48, at 9. *Compare* Edmund Kitch, *The Nature and Function of the Patent System*, 20 J.L. & ECON. 265, 276–79 (1977) (describing the prospect theory of granting broad rights to one company, thus reducing the dissipation of rents at the secondary level), *with* Merges & Nelson, *supra* note 75, at 843–44 (explaining that granting broad patents on building block inventions will increase rent dissipation at the primary level).

89. Fisher, *supra* note 48, at 10.

The outcome of this review is that patent rights are most likely to spur innovation, as the patent laws hope to do, when an industry is subject to the following conditions: "(a) high research-and-development costs; (b) a high degree of uncertainty concerning whether specific lines of research will prove fruitful; (c) the content of technological advances can be ascertained easily by competitors through 'reverse engineering'; and (d) technological advances can be mimicked by competitors rapidly and inexpensively."[90] These conditions came out of the review of the pharmaceutical industry, as most seem to agree that strong patent rights are appropriate in this field, and the industry players place a premium on patent protection.[91]

While the biotechnology industry shares many characteristics with the pharmaceutical industry, Edward Fisher cites an article by John Golden,[92] which indicates three aspects of the biotechnology industry that separate it from the pharmaceutical industry and complicate the determination of patent rights in biotechnology. These are: the large government spending at universities that lead to major innovations; the researchers' desire for nonmonetary reward; and that the industry is highly cumulative.[93] "The convergence of these three factors . . . suggest[s] that the lure of large profits from generous patents for basic discoveries is not necessary to sustain a high level of innovation and that such patents often seriously interfere with research activities."[94]

The aircraft industry seems to put a much lower premium on patents, and tends to rely on lead time and learning-curve advantages to profit from technological advances.[95] In fact, many seem to think that patent protection impeded the progress of the aircraft industry when early broad patents were enforced against rivals.[96] This might have choked the aircraft industry entirely had the government not stepped in by threatening legislation that would have invalidated the Wright brothers' patent.[97]

The software industry began while relying only on trade secret for any legal protection.[98] As the ability to reverse engineer software became easier, the industry sought stronger protections in the forms of first

90. *Id.* at 28.
91. *Id.* at 10–11.
92. *Id.* at 16–18 (citing John M. Golden, *Biotechnology, Technology Policy, and Patentability: Natural Products and Invention in the American System*, 50 EMORY L.J. 101 (2001)).
93. *Id*.
94. *Id.* at 18.
95. *Id.* at 19.
96. *See, e.g.*, *id.* at 20–21; Merges & Nelson, *supra* note 75, at 890–91.
97. *See* Fisher, *supra* note 48, at 21; Merges & Nelson, *supra* note 75, at 891.
98. Fisher, *supra* note 48, at 23.

copyrights and, much later, patents.[99] One commentator questions whether these additional protections truly helped the software industry to continue to innovate since the pace of the industry has not changed though its protections have; the cumulative nature of the industry likens it to the biotechnology arguments above; and because social advantages "arise when all of the users of a particular type of technology adhere to the same standards and thus can share their work and move easily between machines and businesses."[100]

2. Where Does Nanotechnology Fit?

Given the above discussion, nanotechnology appears to be related most closely with the biotechnology industry. Nanotechnology is most certainly characterized by high research and development costs, as any company will be required to invest in expensive tools, secure licensing, and hire talented researchers with specialized skills.[101] And there is little doubt that there exists uncertainty concerning whether particular lines of research will prove fruitful in nanotechnology.[102] But while pharmaceuticals, and arguably biotechnology, can be easily reverse engineered, nanotechnology, even as it progresses to commercial products, will likely not be easily reverse engineered.[103] Additionally, the high costs and the inability to reverse engineer nanotechnology suggest that it is also difficult to mimic advances by competitors. Thus, while nanotechnology has characteristics of two of the factors that point in favor of strong intellectual property rights to foster innovation, the other two do not support the need for strong rights.

Additionally, the three characteristics of biotechnology that called into question the need for strong rights to spur innovation all exist in nanotechnology. The government is funding much of the base research as part of its initiative to make the United States a nanotechnology superpower.[104] And the government will keep funding nanotechnology in the foreseeable future, as it recognizes that the private investment market

99. *Id.* at 23–24.

100. *Id.* at 24–25.

101. MILLER ET AL., *supra* note 3, at 140, 189.

102. *E.g.*, Manya S. Deehr & Mary Ann Stretch, *Essentials of Licensing Biotechnology, Nanotechnology, and Other Cutting-Edge Technologies*, *in* LICENSING BEST PRACTICES: STRATEGIC, TERRITORIAL, AND TECHNOLOGY ISSUES 151 (Robert Goldscheider & Alan H. Gordon eds., 2006).

103. *See* Beard & Halluin, *supra* note 70, at 25 (describing how trade secret protection is useful for products that are typically more difficult to reverse engineer); Lemley, *supra* note 27, at 617; *Transcript of the Live Symposium Interdisciplinary Approaches to Medical Nanotechnology: Defining the Issues*, 6 IND. HEALTH L. REV. 385, 410 (2009).

104. *See supra* notes 19–24 and accompanying text.

may not be willing to wait for the technology to mature.[105] Though more patents are being held by universities, it is not certain researchers are patenting to capitalize on the commercialization of their findings. Indeed, alternate explanations exist. For example, "In the scientific community, patents can bolster a researcher's reputation and enhance his or her resume."[106] Additionally, "Researchers have been known to explore paths to satisfy their own interests rather than maintaining lockstep progress toward a commercial goal."[107] And it is definitely arguable that nanotechnology will proceed cumulatively, building on previous inventions to further the technology.[108] Like the biotechnology industry, these characteristics suggest that strong patent rights are not required to foster innovation in the nanotechnology industry.

Along with these characteristics from the biotechnology industry, "[t]he likelihood that intellectual-property rights will impede more than stimulate innovation [also] increases" when trade secret protection is available.[109] While patents play an important role in an emerging technology, it would not be surprising to find that some companies are relying on a combination of patents and trade secrets to protect their intellectual property. Indeed, "The nature of nanotechnology research and development presents ample opportunities for generating trade secrets."[110] In many instances, companies may favor trade secret protection over patent protection because enforcement of patent rights in nanotechnology is difficult due to the difficulty in detecting infringing activities.[111] Thus, if companies are in fact pursuing both patent and trade secret protection, then it is possible that "the number of nanotechnology patents *understates* the innovation occurring in the field," and acts as another reason why strong patent protection is not necessary to spur innovation.[112]

Thus, a review of these factors for determining the appropriate strength of patent rights suggests that nanotechnology should be afforded

105. *See supra* note 19 and accompanying text; MILLER ET AL., *supra* note 3, at 196 ("Nanotech cannot yet provide the customary tenfold returns on investment within five years, or fivefold returns within three years, which are usually expected by VCs." (internal quotations omitted)). *See generally* NNI 2011 BUDGET, *supra* note 21 (describing current funding efforts, research initiatives, and goals).

106. Serrato, Hermann & Douglas, *supra* note 27, at 152.

107. Deehr & Stretch, *supra* note 102, at 151.

108. *See* Miller & Harris, *supra* note 62, at 437 (describing that a particular property of a broad patent may still be patentable); Sabety, *supra* note 37, at 513–14.

109. Fisher, *supra* note 48, at 28–29.

110. Scott W. Cummings, *The Role of Trade Secrets in Today's Nanotechnology Patent Environment*, 5 NANOTECHNOLOGY L. & BUS. 41, 47 (2008). *Accord* Lemley, *supra* note 27, at 617.

111. Beard & Halluin, *supra* note 70, at 24–25; Lemley, *supra* note 27, at 623.

112. Lemley, *supra* note 27, at 617.

even weaker rights than biotechnology, as a result of the ample possibility for trade secret protection to be used in conjunction with patent protection. In addition to this argument, the economic effects of patent scope can also be taken into account to help determine the appropriate strength and breadth of patent rights.

B. THE EFFECT OF BROAD PATENT SCOPE

Claim scope, and how law and policy respond to it, can shed light on the strength of patent rights that should be afforded to a given technology. Patent prosecution practice in the United States on pioneering patents tends to favor broad patent scope under the enablement doctrine.[113] If an examiner cannot find an embodiment of the claimed invention in the prior art, "patent office policy dictates that even very broad claims may be allowed. This means that claims to pioneer inventions often are allowed to cover ground that examiners *believe*, but cannot prove, is well beyond the area actually explored and disclosed by the inventor."[114] The patent landscape of nanotechnology tends to give even more strength to this point, as the questionable patents that were issued early were due in part to the disorganization of the USPTO when the flurry of nanotechnology patent applications began coming in.[115] The rationale behind this policy is that doing otherwise would put too much power in a single examiner's hands, and any narrowing can be done by the courts.[116] But what seems contrary to this rationale is that under the doctrine of equivalents, courts tend to stretch the reach of patent claims, even more so when the patent is a pioneering one.[117] Thus, when an improvement patent is issued, it is common that it will be blocked from practice in the absence of a license because it would infringe a previous foundational patent.[118] This situation can give rise to the holdup problem discussed above, with the foundational

113. *See* Merges & Nelson, *supra* note 75, at 848.

> Under section 112, the disclosure must be sufficient to enable someone skilled in the art to make and use all the embodiments of the invention claimed in the patent. This requirement can at times be applied rather loosely: a specification that describes only one working example of an invention but that supplies less guidance on the subject matter at the fringes of a patent's claims is often sufficient.

Id. at 845.

114. *Id.* at 848–49.

115. *See supra* note 29 and accompanying text.

116. *See* Merges & Nelson, *supra* note 75, at 849; Ellen P. Winner, *Enablement in Rapidly Developing Arts—Biotechnology*, 70 J. PAT. & TRADEMARK OFF. SOC'Y 608, 619–23 (1988).

117. 5B DONALD S. CHISUM, CHISUM ON PATENTS § 18.04[2] (2007); Merges & Nelson, *supra* note 75, at 854.

118. *See* Merges & Nelson, *supra* note 75, at 860–65.

patentee trying to extract royalties from the improver.[119]

Not all the literature, however, suggests that broad foundational patents are a bad thing. Most notably is Edmund Kitch's work on his prospect theory of patent rights.[120] Because patents are granted after invention but before commercialization, there are two advantages: "(1) it allows 'breathing room' for the inventor to invest in development without fear that another firm will preempt her or steal her work; and (2) it allows the inventor to coordinate her activities with those of potential imitators to reduce inefficient duplication of inventive effort."[121] This model, of course, assumes that the rights holders will continue to innovate and orchestrate the development of the technology with all comers rather than become complacent with the current technology and their market position that allows them to extract royalties.[122] This state of affairs can also lead to stifling the commercialization of a given technology.[123] Historically, in cumulative technologies, a broad pioneering patent was most likely the cause of stifled innovation, either through the threat of litigation or by increasing the cost of participating in the market by exacting royalty payments.[124] By contrast, where "there were no broad patents to discourage entry, entry was easy and competition for improvements was intense."[125]

The radio industry, which is also classified as a cumulative technology, is an interesting example. Much like nanotechnology, the early radio industry was characterized by foundational patents privately owned by diverse and competing entities.[126] Like the aircraft industry in the days

119. *Id.* at 865–66; *supra* notes 74–76 and accompanying text.

120. *See* Merges & Nelson, *supra* note 75, at 871 (citing Kitch, *supra* note 88, at 276–77, 279).

121. *Id.*

122. *See* Merges & Nelson, *supra* note 75, at 872–74. *See also* Lemley, *supra* note 27, at 623 ("[A] single firm with central control over product development is unlikely to foresee or be able to exploit all of those uses.")

123. *See* Lemley, *supra* note 27, at 618–19 & n.82; Merges & Nelson, *supra* note 75, at 884–904 (discussing the impediment of the electrical lighting, automobiles and airplanes, radio, semiconductors and computers, and chemical industries due to excessive patent scope).

124. *See* Merges & Nelson, *supra* note 75, at 884–91. Note that Robert Merges and Richard Nelson put biotechnology in a separate category: science-based industries. Science-based industries are characterized by "research and development efforts [that] attempt to exploit recent scientific developments. These scientific developments tend to narrow and focus perceived technological opportunities in the industry and concentrate the attention of inventors on the same things." *Id.* at 883. While they offer little insight into the effect of patent scope in these industries, due mostly to the timing of the publication, they do indicate that the USPTO should be careful in its granting of claim scope since the technology straddles the areas of public scientific knowledge and private intellectual property. *Id.* at 882.

125. *Id.* at 887.

126. *See id* at 891–92; Sabety, *supra* note 37, at 496–97. Sabety argues that radio is the best comparison for nanotechnology when trying to determine what intellectual property policies will

of the Wright brothers,[127] these competing entities asserted their patent rights, giving rise to the holdup problem and expensive litigation.[128] The patent deadlock remained until the birth of the Radio Corporation of America ("RCA"), which acquired the rights to numerous radio patents at the behest of the U.S. Navy so that a single supplier could furnish radios to them.[129] Thus, radio can be described as "a canonical instance where the presence of a number of broad patents, which were held by different parties and were difficult to invent around, interfered with the development of the technology."[130] Ted Sabety is not ready to say that the development of the technology was impeded by the patent landscape, but he does concede that the patent concentration of the RCA caused a number of companies to go out of business before Congress was able to induce the RCA to adopt a nonexclusive licensing policy with fewer restrictions on a licensee's qualifications.[131] But Sabety's conclusion that innovation was not stifled could simply be a result of the government sponsorship of the RCA and developing firms' hopes of inclusion or favorable licensing conditions.[132] In response to the suggestion that the RCA would have developed even in the case of narrow patent scope, Robert Merges and Richard Nelson are skeptical.[133] In fact, Merges and Nelson conclude that there is "no guarantee that pooling, cross licensing, or consolidation will always emerge to break an industry impasse."[134] Thus, with broad claim scope on foundational patents, it should be expected that an impasse of patent rights will emerge.

Though it is clear that broad patents have been issued in nanotechnology, there is no indication yet that any one company is sitting on its patent rights; but by the same token, the segmentation of patent rights does not position any one patent holder to facilitate the development of the technology as the prospect theory would suggest. In this situation, "in multicomponent products, broad patents on different components held by several inventors may lead to a situation in which no one can or will

promote growth not only because the patents are privately owned by diverse entities, but also because any public funding can be classified as private because of the Bayh-Dole Act, because there is a weakened sense of antitrust treatment towards concentrations of patent rights, and because the "[p]atentability of [n]anotechnology [is] [g]enerally [n]ot in [d]oubt." Sabety, *supra* note 37, at 503–07.

127. *See supra* notes 96–97 and accompanying text.

128. *See* Merges & Nelson, *supra* note 75, at 892; Sabety, *supra* note 37, at 496–97.

129. *See* Merges & Nelson, *supra* note 75, at 893; Sabety, *supra* note 37, at 498–99.

130. Merges & Nelson, *supra* note 75, at 892–93.

131. *See* Sabety, *supra* note 37, at 500–03.

132. Lemley, *supra* note 27, at 621.

133. *See* Merges & Nelson, *supra* note 75, at 894–96.

134. *Id.* at 896.

advance the technology in the absence of a license from someone else."[135] To date, there has not been much evidence of bitter patent litigation, possibly because patent infringement in nanotechnology is difficult to detect.[136] This practice of ignoring possible infringing activities may continue through the research stage, but will be more difficult to ignore once products start appearing in the market, and it has no effect on the potential for excessive concentration and monopolization of patent rights.[137]

IV. INTELLECTUAL PROPERTY POLICIES AND TOOLS TO LEAD NANOTECHNOLOGY TO COMMERCIALIZATION

While Sabety does not necessarily agree that innovation was stifled in the radio industry, he also does not see the radio industry as the model to promote economic growth as the government hopes to do. Sabety believes that the information technology industry was the last "economic miracle" and that law and policymakers should strive to treat nanotechnology like the information technology industry if economic growth is a major driver.[138] The early information technology industry of the 1950s "occupied an entirely different intellectual property, anti-trust and funding policy context than that of nanotechnology today," and it was not until the industry was established that "stronger intellectual property . . . rights arose."[139] Thus, in accord with the review of the factors discussed in Part III above, Sabety argues that early nanotechnology should be shepherded in under a weaker intellectual property regime than is currently in existence. The arguments and policies to promote growth and the commercialization of the nanotechnology industry are taken up in this part.

As mentioned above, the patent thicket problem can typically be cured by coordination among the industry players.[140] But "[e]ven as coordination between rights holders is critical, from a public policy perspective we cannot presume that private deals are in the public interest," and, thus, antitrust concerns come into play.[141] Additionally, with the complex patent

135. *Id.* at 882.

136. *See* Beard & Halluin, *supra* note 70, at 24; Lemley, *supra* note 27, at 623. *But see* Christiansen et al., *supra* note 81, at 374–75; William F. Prendergast & Heather N. Schafer, *Nanocrystalline Pharmaceutical Patent Litigation: The First Case*, 5 NANOTECHNOLOGY L. & BUS. 157, 157 (2008) (describing an early case of nanotechnology litigation).

137. *See* Lemley, *supra* note 27, at 623.

138. Sabety, *supra* note 37, at 480–81.

139. *Id.* at 480.

140. *See supra* note 82 and accompanying text.

141. Shapiro, *supra* note 70, at 127.

landscape and its many different rights holders claiming stake, we should not expect that ample coordination will occur on its own.[142]

A. CROSS LICENSING

A holder of a broad patent right on an upstream invention has essentially three basic options on how to manage its patent rights: (1) "the patent holder can refuse to license the technology in order to prevent competition with its products"; (2) "the patent holder can grant nonexclusive licenses to anyone wishing to use the technology"; or (3) "the patent holder can grant exclusive licenses to particular firms wishing to develop the technology in a particular manner."[143]

The threat of firms refusing to license their patent rights should not be overlooked in nanotechnology. When patents are distributed asymmetrically across an industry,[144] they can be used as strategic weapons by start-up companies to block competing start-ups from bringing products to market, or by established corporations to prevent start-ups from interfering with their market position, effectively using patent rights to force a competitor out of the market.[145] A review of the market players shows "hundreds of large corporations and hundreds of start-up companies attempting to commercialize nanotechnology-based products."[146] There is no indication that this has been a problem yet in the nanotechnology industry, and rights holders may be wary of possible antitrust concerns regarding the refusal to license their products to a competitor.[147] But the history of litigation in the biotechnology industry suggests that start-ups in direct competition are more likely to litigate their patent rights and put the other out of business rather than find a licensing solution.[148]

142. *See supra* note 134 and accompanying text.

143. MILLER ET AL., *supra* note 3, at 71. For purposes of this Note, field of use exclusive licenses will be considered exclusive licenses.

144. Meaning that "core patents are [not] distributed roughly evenly among firms [of roughly equal size] participating in a market driven by nanotechnology." Lemley, *supra* note 27, at 623.

145. *See* MILLER ET AL., *supra* note 3, at 74; Lemley, *supra* note 27, at 624; Miller & Harris, *supra* note 62, at 451 (describing business strategy on whether to forgo or pursue patent litigation).

146. MILLER ET AL., *supra* note 3, at 33–37, 76.

147. *See* Shapiro, *supra* note 70, at 133, 146 nn.17–18 (noting the inter-circuit split between the antitrust decisions in *Image Technical Services v. Eastman Kodak Co.*, 125 F.3d 1195 (9th Cir. 1997) and *In re Independent Service Organization Antitrust Litigation*, 203 F.3d 1322 (Fed. Cir. 2000)). Indeed, companies may be wary of possible antitrust concerns regarding the refusal to license their products to a customer that is not in direct competition with them. Shapiro documents the FTC's attack on Intel's licensing tactics in response to patent infringement suits brought against Intel by customers using Intel patents. *See* Shapiro, *supra* note 70, at 130–32.

148. *See* Serrato, Hermann & Douglas, *supra* note 27, at 155 (suggesting that start-ups would not

As indicated above, patent rights holders have the option of granting an exclusive or nonexclusive license. In nanotechnology, nonexclusive licenses would be preferred, especially on foundational patents, because they could have applications in numerous areas and would allow more participants to enter these markets and push toward commercialization.[149] Furthermore, nonexclusive licenses have the advantage of lower fees and royalty rates for the licensee and allow the licensor to not become dependent on the success of one particular product.[150] Additionally, nonexclusive licenses allow the licensee to spread some of the risk by creating a joint venture opportunity with another company.[151] Yet, the multi-industry nature of nanotechnology will likely lead to more exclusive licenses, especially when patent holders are licensing outside of their own respective industry. Because some nanotechnology patents may be applicable in industries that the patent holder is not a player, there is less incentive for the patent holder to use its patent rights to exclude use in another industry.[152] But because exclusive licenses tend to draw larger royalty rates than nonexclusive licenses, the patent holder may be incentivized to license its patent exclusively to one developer in that industry, rather than provide a series of nonexclusive licenses.[153] At the research stage, most start-ups will likely seek exclusive licenses, as products under exclusive licenses tend to have longer development cycles, and exclusive licenses reward those willing to take the time and money to bring those products to market with increased revenues.[154] The *Nanotechnology Law and Business Journal* has been documenting publicly disclosed license agreements in nanotechnology since 2003 and shows that the majority of disclosed licenses granted by universities or public research entities, entities likely to hold upstream foundational patents, are exclusive licenses.[155] Indeed it appears that universities are choosing exclusive

need to cross license if they could put their competitor out of business).

149. *See* Lemley, *supra* note 27, at 623; Sabety, *supra* note 37, at 508–09.

150. Bastani et al., *supra* note 34, at 170.

151. *See* Reza Mollaaghababa & Ronald E. Cahill, Canon v. Nano-Proprietary*: Implications for Big Companies That Bring Nanotechnology to the Market*, 4 NANOTECHNOLOGY L. & BUS. 161, 168 (2007).

152. *See* Lemley, *supra* note 27, at 624. That is not to say that it has not happened in other industries. *Id.* at 615.

153. *Id.* at 624.

154. *See* Bastani et al., *supra* note 34, at 170. *But see* Mollaaghababa & Cahill, *supra* note 151, at 168 (noting fashioning nonexclusive licenses that allow for multiple firms to work together might be the best answer).

155. *See Nanotechnology Updates*, 1 NANOTECHNOLOGY L. & BUS. 130, 130–32 (2004); *Nanotechnology Updates*, 1 NANOTECHNOLOGY L & BUS. 232, 232–35 (2004); *Nanotechnology Updates*, 1 NANOTECHNOLOGY L. & BUS. 471, 471–73 (2004); *Nanotechnology Updates*, 1

licenses for nanotechnology more than they did in the case of biotechnology.[156] Thus, as the industry is left to negotiate its own licenses, many are choosing not to freely license their technology to the market, which is contrary to fostering competition and continuing the innovation march toward commercialization of nanotechnology.[157] Further complicating the problem is that not all university licensing departments are well equipped to handle the task.[158]

Cross licensing is most effective between two large companies that control blocking patents to one another,[159] which is not the case with much of nanotechnology because of its segmented patent rights. For example, in the semiconductor industry, cross licensing has worked because "there are a relatively small number of large firms with similar products and similar patent arsenals."[160] Nonetheless, licensing within various areas of nanotechnology has been occurring as necessary to facilitate technology

NANOTECHNOLOGY L. & BUS. 130, 130–32 (2004); *Nanotechnology Updates*, 2 NANOTECHNOLOGY L. & BUS. 121, 121–23 (2005); *Nanotechnology Updates*, 2 NANOTECHNOLOGY L. & BUS. 315, 315–18 (2005); *Nanotechnology Updates*, 2 NANOTECHNOLOGY L. & BUS. 419, 419–24 (2005); *Nanotechnology Updates*, 3 NANOTECHNOLOGY L. & BUS. 107, 107–10 (2006); *Nanotechnology Updates*, 3 NANOTECHNOLOGY L. & BUS. 243, 243–48 (2006); *Nanotechnology Updates*, 3 NANOTECHNOLOGY L. & BUS. 389, 389–94 (2006); *Nanotechnology Updates*, 3 NANOTECHNOLOGY L. & BUS. 561, 561–64 (2006); *Nanotechnology Updates*, 4 NANOTECHNOLOGY L. & BUS. 141, 141–44 (2007); *Nanotechnology Updates*, 4 NANOTECHNOLOGY L. & BUS. 247, 247–50 (2007); *Nanotechnology Updates*, 4 NANOTECHNOLOGY L. & BUS. 407, 407–09 (2007); *Nanotechnology Updates*, 4 NANOTECHNOLOGY L. & BUS. 539, 539–41 (2007); *Nanotechnology Updates*, 5 NANOTECHNOLOGY L. & BUS. 117, 117–19 (2008); *Nanotechnology Updates*, 5 NANOTECHNOLOGY L. & BUS. 245, 245–46 (2008); *Nanotechnology Updates*, 5 NANOTECHNOLOGY L. & BUS. 373, 373–75 (2008); *Nanotechnology Updates*, 5 NANOTECHNOLOGY L. & BUS. 501, 501–03 (2008); *Nanotechnology Updates*, 6 NANOTECHNOLOGY L. & BUS. 140, 140–42 (2009); *Nanotechnology Updates*, 6 NANOTECHNOLOGY L. & BUS. 335, 335–37 (2009); *Nanotechnology Updates*, 6 NANOTECHNOLOGY L. & BUS. 446, 446–49 (2009); *Nanotechnology Updates*, 6 NANOTECHNOLOGY L. & BUS. 546, 546–47 (2009); *Nanotechnology Updates*, 7 NANOTECHNOLOGY L. & BUS. 109, 109–10 (2010); *Nanotechnology Updates*, 7 NANOTECHNOLOGY L. & BUS. 309, 309–10 (2010). Only nine of forty-eight university granted licenses were not listed as exclusive, though most of the nine were under either undisclosed terms or unknown terms.

156. MILLER ET AL., *supra* note 3, at 143.

157. *See supra* Part III; Lemley, *supra* note 27, at 624, 627. *But see, e.g.*, *From the Lab Bench to the Marketplace: Improving Technology Transfer: Hearing Before the Subcomm. on Research and Sci. Educ. of the H. Comm. on Sci. & Tech.*, 111th Cong. 64 (2010) [hereinafter *Technology Transfer Hearing*] (statement of Keith L. Crandell, Co-Founder and Managing Director, ARCH Venture Partners) (stating that exclusive licenses may be necessary for investment-backed start-ups).

158. *See, e.g.*, *Technology Transfer Hearing*, *supra* note 157, at 50 (statement of Wayne Watkins, Associate Vice President for Research, Univ. of Akron), 58–59 (statement of Keith L. Crandell, Co-Founder and Managing Director, ARCH Venture Partners).

159. *See* Shapiro, *supra* note 70, at 127, 129.

160. Serrato, Hermann & Douglas, *supra* note 27, at 155.

transfer.[161] Licensing practice in general is a difficult and costly process. Companies seeking to obtain a license to upstream patents prior to research and development of downstream products will be reluctant to share their plans in the open during negotiations for fear of any misappropriation.[162] Additionally, the uncertainty in nanotechnology products will make it difficult for the parties to value the upstream patent's contributions to the downstream patent's success.[163] Alternatively, companies seeking to license upstream patents after research and development could be subject to the holdup problem and met with unreasonable terms by the upstream patentees seeking to exploit their significant bargaining advantage knowing that the license seekers must obtain a license to avoid an infringement suit.[164] These problems are exacerbated in nanotechnology because most products will require the negotiation of multiple licenses with various companies.[165]

The difficulty of license negotiation is not the only way in which the segmentation of patent rights in nanotechnology makes cross licensing an unlikely solution. The varying business plans and roles of the many players in the nanotechnology industry also make licensing difficult. For example, some firms may be focused on providing only nanomaterials to downstream manufacturers rather than integrating them into products themselves.[166] These companies have little incentive to seek out cross licenses because the companies seeking to license from them have no patents to license back.[167] Thus, they will be in a better position to negotiate the terms of the license in their favor and to require money in exchange for use of their patent.[168] And, as mentioned above, patent rights holders from other sectors of the industry similarly have no incentive to cross license patents and will likely end up granting exclusive licenses for a fee.[169]

161. *See, e.g.*, *Nanotechnology Updates for Spring 2009: Publicly Announced Intellectual Property License Agreements Between December 25, 2008 and March 15, 2009*, 6 NANOTECHNOLOGY L. & BUS. 140, 140 (2009).

162. MILLER ET AL., *supra* note 3, at 74.

163. *Id.* at 74–75.

164. *Id.* at 75.

165. *Id.*

166. "The majority of Fortune 500 companies, including [DuPont, General Electric, General Motors, Hewlett-Packard, IBM, Motorola, and Xerox], are devoting substantial time and liquid capital into researching nanotechnology in hopes of gaining a competitive edge *in their particular market*." BERUBE, *supra* note 7, at 221 (emphasis added).

167. *See* MILLER ET AL., *supra* note 3, at 76–77; Lemley, *supra* note 27, at 624–25; Miller & Harris, *supra* note 62, at 451; Serrato, Hermann & Douglas, *supra* note 27, at 155.

168. *See* Lemley, *supra* note 27, at 624–25; Serrato, Hermann & Douglas, *supra* note 27, at 155.

169. *See* Lemley, *supra* note 27, at 624; Miller & Harris, *supra* note 62, at 451 (noting larger

Thus, cross licensing is unlikely to help clear that patent thicket for nanotechnology because of the asymmetry of the market players and the segmentation of rights across various sectors within the industry. Licensing will continue to occur, but just as often a company may decide to try and push a competitor out of the market by initiating a costly litigation that may be too much for a start-up to bear.[170]

B. PATENT POOLS

Patent pools involve a single entity, in some cases a newly formed entity, licensing the patents of multiple companies as a package among the members of the pool and to third parties.[171] They have the advantage of reducing transaction costs associated with traditional cross-license agreements by reducing the number of negotiations and various licenses needed to advance a given product.[172] Additionally, they offer the benefits of increasing the incentive to innovate improvement patents that may be subject to "blocking patents" by reducing licensing costs for the improver; and they offer a more efficient alternative to costly patent litigation when a patent of questionable validity or one of questionable scope is a part of the pool.[173] To escape antitrust concerns, patent pools must ensure that the patents included and licensed are essential and complementary, as opposed to substitutes and rival patents.[174] Including patents that are merely substitutes and rivals typically leads to less competition in the market and can command higher licensing fees.[175]

Patent pools are no new advent and have come and gone throughout American history, starting as early as 1856 with sewing machine patents.[176] Some, however, such as the patent pool created in the aircraft industry in 1917 at the behest of the U.S. Navy, were eventually dissolved on antitrust

companies may choose to litigate against start-ups because of funding and legal experience advantages).

170. *See supra* note 81. Even cross licensing as the result of a patent litigation may be contrary to the public interest by reducing competition and is subject to antitrust scrutiny when the settlement is between horizontal competitors. *See* U.S. DEP'T OF JUSTICE & FED. TRADE COMM'N, ANTITRUST GUIDELINES FOR THE LICENSING OF INTELLECTUAL PROPERTY §§ 3.1, 5.5 (Apr. 6, 1995).

171. Shapiro, *supra* note 70, at 134.

172. *See* MILLER ET AL., *supra* note 3, at 80; Alexander Lee, *Examining the Viability of Patent Pools for the Growing Nanotechnology Patent Thicket*, 3 NANOTECHNOLOGY L. & BUS. 317, 317 (2006); Carol M. Nielsen & Michael R. Samardzija, *Compulsory Patent Licensing: Is It a Viable Solution in the United States?*, 13 MICH. TELECOMM. TECH. L. REV. 509, 530 (2007).

173. *See* Nielsen & Samardzija, *supra* note 172, at 530.

174. *See* Shapiro, *supra* note 70, at 134.

175. *See id*.

176. *See, e.g.*, MILLER ET AL., *supra* note 3, at 76.

grounds.[177] Antitrust has disrupted patent pools in the past because most resorted to the type of cartel behavior that antitrust is meant to attack.[178] It seems, however, as though the lack of patent pools in the modern era could be due to "excessive deterrence."[179] While the Department of Justice may have been critical of patent pools in the past, the recent decisions on the patent pools of the MPEG-2 and DVD formats show that the Department of Justice does not believe that patent pools are always anticompetitive.[180] Some commentators believe that antitrust should be enforced in a way that takes into account the current state of operating a business under our patent laws.[181]

While the sentiment about patent pools at the Department of Justice may be changing, that does not mean that patent pools are necessarily a solution to the nanotechnology patent thicket. Patent pools may not be a solution for the same reasons as those indicated above for cross licensing. Specifically, the asymmetry of the companies involved may not incentivize the companies with foundational patents or larger patent portfolios to create a pool with those companies wishing to commercialize a product using the foundational patent, but who may not have such a vast patent portfolio to contribute to the pool.[182] And similarly, those who wish only to deal in nanomaterials will have no use for patents held by companies seeking to commercialize products based on the nanomaterials patents.[183] Additionally, it is important to note that these two recent decisions by the Department of Justice represent standards-setting technologies—meaning that the industry agreed on a standard format and the patents in the pools were essential to practice this format.[184] By contrast, in some nanotechnology sectors where the path to commercialization is vertically segmented—such as carbon nanotubes—and no specific industry standards exist, "[e]fforts to establish patent pools . . . would likely trigger strict antitrust scrutiny from the Department of Justice."[185]

As this indicates, patent pools are not necessarily suited for all

177. Fisher, *supra* note 48, at 21.

178. *See, e.g.*, Robert P. Merges, *Institutions for Intellectual Property Transactions: The Case of Patent Pools*, *in* EXPANDING THE BOUNDARIES OF INTELLECTUAL PROPERTY: INNOVATION POLICY FOR THE KNOWLEDGE SOCIETY 123, 157 (Rochelle Dreyfuss et al. eds., 2001).

179. *Id.* at 158.

180. *See id.* at 160–62.

181. *See, e.g.*, *id.* at 158; Nielsen & Samardzija, *supra* note 172, at 529.

182. MILLER ET AL., *supra* note 3, at 76.

183. *Id.* at 76–77.

184. *See* Merges, *supra* note 178, at 161–62; Miller & Harris, *supra* note 62, at 452–53.

185. Miller & Harris, *supra* note 62, at 453.

markets. One commentator has offered nine criteria for determining the viability of a patent pool in any given market.[186] The criteria consist of whether there is: (1) product development driven by standards; (2) moderate fragmentation of patent landscape; (3) at least five pool members; (4) each member working on specific subcomponent of a product; (5) willingness of patent holders to negotiate; (6) commitment by members to create the pool; (7) an industry that is in the later stages of product development; (8) certainty of patent ownership; and (9) a patent pool clear of potential antitrust violations.[187] Several of these criteria, such as being in the later stages of product development and certainty of patent ownership, point away from patent pools in some sectors of nanotechnology.[188] Thus, not only is there little incentive for patent pools to develop on their own within the industry, they also may not be appropriate at this juncture for all sectors of nanotechnology. If that is the case, it suggests that the industry is ill equipped to create proper patent pools that will facilitate the commercialization of nanotechnology.

C. VERTICAL INTEGRATION

One way downstream product manufacturing companies can avoid the need to negotiate licenses with upstream manufacturers is to simply buy the upstream research company that controls the patents the downstream company needs.[189] Not only does this alleviate the possibility of infringement, but it may also put the downstream company in a more symmetrical position with firms both upstream and downstream from it if it acquires patents that may be valuable.[190] But it is unlikely that start-ups attempting to develop a product have the resources necessary to purchase upstream research houses. If, however, vertical integration became something of a trend in nanotechnology, it would have the benefit of consolidating patent rights to fewer rights holders, thus helping to clear the patent thicket and "reduce[] the risk of holdup."[191] But this may not always be possible, since it is often universities that hold the upstream patents, and

186. Lee, *supra* note 172, at 318.

187. *Id.* at 318, 326.

188. This is not to say that all sectors of nanotechnology are the same. For example, in reviewing these criteria for dendritic nanotechnology, Lee notes that there is not much of a patent thicket that needs curing because most of the patent rights in this sector have been consolidated with one company, thus having no incentive to share this patent portfolio absent any interference from the Department of Justice's antitrust enforcement. Lee, *supra* note 172, at 326–27.

189. Lemley, *supra* note 27, at 625.

190. *Id.*

191. *Id.*

they are not capable of vertically integrating with market participants.[192] But often times the inventors of a patent arising from university research will found a company and will negotiate for the patent to be licensed to the inventors to further develop the technology for commercialization.[193] In a similar vein, it seems that the National Science Foundation promotes the approach of creating partnerships at the upstream level between universities and the private sector.[194] Furthermore, at the rate that universities seem to be offering exclusive licenses,[195] partnerships may have an effect similar to vertical integration if these start-ups are able to truly develop the technology for commercialization.

Vertical integration can also implicate antitrust, as consolidating companies that are in the same field of endeavor can lead to decreased competition by promoting a monopoly. This is precisely the thought behind the Department of Justice's innovation market theory. Under the theory, "a merger of two companies whose sole aspect of competition was in the same field of scientific research could be blocked in order to prevent the advancements produced by such research to be owned by one entity."[196] More recently, however, the Department of Justice has demonstrated that it will not necessarily block a merger of companies that are still in the early stage of research.[197] Though, if the Department of Justice were to allow vertical integration as described above, consolidating upstream and downstream companies, it would not just include companies engaged in early stage research. Indeed, given that the NNI seeks to ensure that nanotechnology is spread across many companies, this goal would not be served if large corporations were able to simply buy up the foundational intellectual property.[198] Thus, vertical integration may not be able to escape antitrust scrutiny if the desire is to consolidate intellectual property both up and downstream.

D. REEXAMINATION AND PATENT VALIDITY

As mentioned above, one way to help cure the holdup problem is to allow possible infringers the ability to challenge the validity of a patent.[199]

192. *Id.* at 626.
193. MILLER ET AL., *supra* note 3, at 36.
194. *See, e.g.*, *Technology Transfer Hearing*, *supra* note 157, at 5.
195. *See supra* notes 154–57 and accompanying text.
196. Sabety, *supra* note 37, at 505.
197. *See id.* at 505–06.
198. *See id.* at 510.
199. *See supra* note 83 and accompanying text.

The USPTO and the patent laws allow for a limited challenge through the reexamination administrative hearing.[200] The reexamination proceeding allows anyone to challenge the validity of a patent by offering a prior art reference of either a previous patent or printed publication.[201] The inter partes reexamination provides a number of features that make it an attractive tool for patent infringement defendants, including the following: beginning a reexamination proceeding will stay a patent litigation until conclusion of the reexamination; the USPTO will apply the broadest possible claim construction during reexamination; the patent owner is under a duty to disclose any information material to the patentability of any claim; the lack of discovery, usually an expensive ordeal in litigation; review of the patent claims by an expert in the field that was not the original patent examiner; and a claim cancelled as the result of a reexamination may not be enforced in any subsequent patent litigation.[202]

Reexamination may be a viable solution for many of the early nanotechnology patents. Carbon nanotubes are the materials typically discussed when it comes to their not being patentable over prior art that was in existence when the first nanotube patents were filed. There seem to be numerous articles and some patents that seem directed at carbon nanotubes.[203] One such article was even part of the examination of one of the early carbon nanotube patents, but the examiner accepted a nonfactual argument from the patent prosecutor to overcome his anticipation rejection.[204] To some degree, the doctrine of inherency should help an argument of anticipation in a reexamination.[205] These arguments of anticipation should be raised again with the USPTO now that the office has had more experience with nanotechnology patents. As much of the literature focuses on carbon nanotubes, however, it may be that such a reexamination to invalidate nanotechnology patents is in fact limited to the nanotube sector. But while reexamination may not lead to the invalidation

200. *See generally* 35 U.S.C. §§ 301–318 (2006) (statutes covering ex parte and inter partes reexamination).

201. *See* Christiansen et al., *supra* note 81, at 375.

202. *Id.* at 376–77.

203. *See, e.g.*, Miller & Harris, *supra* note 62, at 444–48; Ted Sabety, *The Doctrine of Inherency and the Carbon Nanotube Patents: Experimental Measures vs. Documentary Inference*, 17 ALB. L.J. SCI. & TECH. 737, 746–47 (2007).

204. *See* Sabety, *supra* note 203, at 746.

205. *See* Miller & Harris, *supra* note 62, at 447–48; Sabety, *supra* note 203, at 746–47. "The doctrine of inherent anticipation is simply formulated: '[i]t is well settled that a prior art reference may anticipate when the claim limitations not expressly found in that reference are nonetheless inherent in it.'" Sabety, *supra* note 203, at 743 (quoting *In re* Cruciferous Sprout Litig., 301 F.3d 1343, 1349 (Fed. Cir. 2002)).

of many nanotechnology patents, its usefulness as a litigation tool should not go overlooked.

While the reexamination proceeding is limited to a reexamination based on prior art, a patent may still be found invalid through full litigation. There are numerous ways in which nanotechnology patents could be found invalid.[206] Indeed, at least one commentator has suggested that the industry could expend some resources to show that carbon nanotubes are inherent in the prior art processes.[207] Such a discussion of nanotechnology patent validity is beyond the scope of this Note, but it should be recognized as a way, albeit an expensive one, in which nanotechnology patents can be reviewed for validity.

E. Patent Expiration

Because early nanotechnology was so heavily patented, it is possible that many of the upstream foundational patents will expire before commercial products based on them become viable. Indeed, "because universities do early stage research, they patent inventions that are far from commercialization; they may therefore actually speed the entry of some inventions into the public domain by obtaining patents that expire earlier."[208]

For example, of the three most commonly cited carbon nanotube patents, the earliest will expire in the year 2013 and the latest in 2019.[209] Because each of these are composition of matter claims, any downstream product or process incorporating carbon nanotubes falling under their claims will be infringing, absent a license.[210] But once these patents expire, anyone may use carbon nanotubes without fearing infringement litigation. But near term products that can be developed now, such as field emitting devices, incorporate carbon nanotubes.[211] Thus, firms will still have to negotiate licenses to continue developing these products now to ensure they will not be sued for infringement. And depending on their business model,

206. *See* Miller & Harris, *supra* note 62, at 442–49; Rao, *supra* note 5, at 847–56.

207. *See* Sabety, *supra* note 203, at 751.

208. Lemley, *supra* note 27, at 626.

209. Sabety, *supra* note 203, at 739 fig.1. *See also* U.S. Patent No. 5,424,054 (filed May 21, 1993); U.S. Patent No. 5,747,161 (filed Oct. 22, 1996); U.S. Patent No. 6,683,783 (filed Dec. 22, 1999). Of course, the patent laws allow a statute of limitations of six years, which effectively pushes these dates out six more years for purposes of this discussion.

210. *See* Miller & Harris, *supra* note 62, at 437; Sabety, *supra* note 203, at 740.

211. Shaddox, *supra* note 4, at 167; Mouttet, *supra* note 87, at 314–17 (detailing the emission properties and uses of carbon nanotubes).

if they are synthesizing their own carbon nanotubes, they will still need to secure licenses for nanotube process patents. Futhermore, carbon nanotubes are but one sector in the broad nanotechnology landscape, and have arguably been known to the scientific community since the 1970s.[212] Newer developing nanotechnologies will likely not be able to rely on patent expiration as the carbon nanotube sector may be able to do.

F. JUDICIAL INTERPRETATION

The patent laws are, for the most part, "technology-neutral"; meaning that the same laws apply regardless of the underlying technology.[213] While this is the ideal, the simplicity allows for liberal judicial freedom and policy making.[214] For example, it appears that in the biotechnology industry, the Federal Circuit has tried very hard to ensure that the patents are found to be nonobvious, which decreases the threshold for patentability, but at the same time, it has also imposed stringent enablement and written description requirements, which increases the threshold for patentability.[215] There is similar freedom at the USPTO as well, as it seems that different industries are treated differently by the USPTO given that the patent applications are routed to the various examination groups of different expertise.[216] Dan Burk and Mark Lemley argue that there exist "policy levers" in the patent laws that can, and should, be used by the judiciary to tailor the patent laws to various technologies.[217]

While the judiciary has refused to acknowledge any such industry-specific patent policy, to some degree the judiciary is cognizant of this ability.[218] Utility is one area in which the judiciary most certainly applied a higher standard in biotechnology and chemistry.[219] In a similar fashion, "imposing a strict utility requirement" in nanotechnology can help take strong patent protection away from the upstream patents to the downstream patents that are related to commercial products.[220]

212. *See, e.g.*, Miller & Harris, *supra* note 62, at 444–45.

213. *See* Burk & Lemley, *supra* note 82, at 1577.

214. *Id.* at 1577–78 (noting that the different treatment of various industries by the courts is not necessarily well reasoned).

215. *Id.* at 1593.

216. *Id.* at 1590–91.

217. *Id.* at 1640. The existing policy levers identified are: abstract ideas, utility, experimental use, level of skill in the art, secondary considerations of obviousness, written description, reasonable interchangeability, pioneering patents, and reverse doctrine of equivalents. *Id.* at 1642–58.

218. *See id.* at 1577–78.

219. *Id.* at 1644–46.

220. Lemley, *supra* note 27, at 628.

The level of ordinary skill in the art is, by its very nature, wholly industry-specific.[221] The level of ordinary skill is a part of the patent validity questions of obviousness, enablement, written description, best mode, and the definiteness and construction of patent claims.[222] When applied by the courts, the written description requirement can have a narrowing effect on patent scope by comparing the breadth of the claims with the disclosure made in the written description.[223] This is similarly true of the enablement doctrine.[224] And in *Phillips v. AWH Corp.*, the Federal Circuit explained that in conducting Markman hearings construing the claims of a patent, the written description is a key contributor to the meaning of claim terms.[225] This is another way in which the level of ordinary skill in art can be used by the judiciary to refine patent scope, and those companies having difficulty securing the necessary licenses can use this as a weapon in subsequent litigation.[226] Yet, the multi-industry nature of some nanotechnology patents may complicate this some because typically commentators suggest specific patent policy for various industries, and the Federal Circuit has similarly set up different precedents for different industries, which may not be appropriate when the same nanotechnology inventions can be used in various industries.

It seems unlikely that the judiciary is willing to take on the challenge of providing patent policy for each industry.[227] Indeed, with nanotechnology, only time will tell as very few nanotechnology patent cases have made it to courts as of yet. But if the Federal Circuit continues to shy away from its patent policy role, relying heavily on judicial interpretation to clear the patent thicket is not recommended.

G. GOVERNMENT INTERVENTION

As shown in Part III, a somewhat weak set of patent rights is desirable for nanotechnology. And the options discussed thus far in this part appear to be cumbersome and unlikely to resolve the patent thicket problems

221. Burk & Lemley, *supra* note 82, at 1650.

222. *Id.* at 1648–50.

223. *See* J. Peter Paredes, Note, *Written Description Requirement in Nanotechnology: Clearing a Patent Thicket?*, 88 J. PAT. & TRADEMARK OFF. SOC'Y 489, 499 (2006). *See also* Burk & Lemley, *supra* note 82, at 1653–54 (describing the written description requirement effects in biotechnology patents).

224. *See* MILLER ET AL., *supra* note 3, at 221–22.

225. Phillips v. AWH Corp., 415 F.3d 1303, 1313–15 (Fed. Cir. 2005).

226. *See* Paredes, *supra* note 223, at 499–500 (noting that a claim construed broadly in a hearing may not satisfy the written disclosure requirement in later litigation).

227. *See* Burk & Lemley, *supra* note 82, at 1671–73.

without some prodding from outside the industry. If the government wishes to instill an economic revolution, "the foundational IP should be widely licensed while the narrow refinements or follow-on innovations should receive exclusivity to attract private capital."[228]

As mentioned above, patent pools have several benefits that could facilitate the timely development of downstream nanotechnology products.[229] But as discussed, these structures are unlikely to arise on their own due to the asymmetry of the companies involved.[230] But this does not stop the government from encouraging the formation of such patent pools as it has done in the past with the automobile, radio, and aircraft industries.[231] Some suggest that a committee of technology exchange officers from the USPTO would be an excellent starting point for the design of the frameworks necessary for useful patent pools.[232] Government involvement at the outset would have a number of benefits. If patent pools are sponsored by the government, the legal uncertainties associated with antitrust concerns that may keep some companies away from patent pools could be alleviated.[233] Additionally, the government could ensure that the cartel behavior often associated with patent pools is prevented.[234] Government action could also act as the "catalyst necessary to form the pools," and overcome some of problems associated with the initial formation of patent pools.[235] Lastly, the "government might be able to leverage its funding commitments to entice participation."[236] But commentators are not sold on the ability of the government to foster these patent pools, due mainly to the same reasons the industry will not be able to create patent pools.[237] Specifically, these commentators believe that the government will be unable to overcome the strong disincentive for participation and the complications associated with pool formation.[238] The NNI, which is coordinating the United States' efforts in nanotechnology, commands a considerable budget.[239] Indeed, one of the NNI's four main

228. Sabety, *supra* note 37, at 508.
229. *See supra* notes 172–73 and accompanying text.
230. *See supra* notes 182–83 and accompanying text.
231. MILLER ET AL., *supra* note 3, at 81; Sabety, *supra* note 37, at 498.
232. MILLER ET AL., *supra* note 3, at 81; Merges, *supra* note 178, at 159.
233. MILLER ET AL., *supra* note 3, at 81.
234. *See id.*
235. *Id.*
236. *Id.*
237. *See, e.g.*, *id.*
238. *See, e.g.*, *id.* at 81–82.
239. *See supra* notes 22–24 and accompanying text.

goals is to ensure the commercialization of nanotechnology.[240] Under the umbrella of this goal, the NNI could fund analysis of how best to form patent pools and possibly determine ways to incentivize the players to come together in the march toward commercialization. Thus, the government may already have an agency that is well positioned to get around the problems that the industry would face if it tried to create patent pools on its own.

The commentators also point out that patent pool formation in the past was always accompanied by the threat of compulsory licensing.[241] But nothing stops the government from making similar threats now. Indeed, some commentators believe that any patents obtained under the Bayh-Dole Act should be made publicly available.[242] The Bayh-Dole Act affords the government numerous rights with regards to inventions made with public funding. Most importantly, the Act provides the government with so-called march-in rights, as well as a license to practice, or have practiced, the subject invention.[243]

Under the Bayh-Dole Act, the government's march-in rights give it the authority to grant compulsory licenses to inventions made with federal assistance, which would likely cover a large number of nanotechnology patents, including those obtained by universities.[244] Under the Act, compulsory licenses may be granted when the recipient of federal funds "has not taken, or is not expected to take within a reasonable time, effective steps to achieve practical application of the subject invention in such field of use."[245] Granting of compulsory licenses is also authorized when "necessary to alleviate health or safety needs" or "necessary to meet requirements for public use specified by Federal regulations and such requirements are not reasonably satisfied by" the rights holder.[246] Compulsory licensing seems to make the most sense when a patent holder is using the patent only to extract a royalty, rather than practicing the invention.[247] But they can also be appropriate in limited situations to limit

240. *See* NNI 2011 BUDGET, *supra* note 21, at 3–4 ("(2) foster the transfer of new technologies into products for commercial and public benefit").

241. *See* MILLER ET AL., *supra* note 3, at 82.

242. *See, e.g.*, *Technology Transfer Hearing*, *supra* note 157, at 67 (statement of Neil D. Kane, President and Co-Founder, Advanced Diamond Techs., Inc.).

243. *See* 35 U.S.C. §§ 202(c)(4), 203(a) (2006).

244. *See id.*§ 203(a); Lemley, *supra* note 27, at 628; Nielsen & Samardzija, *supra* note 172, at 534.

245. 35 U.S.C. § 203(a)(1).

246. *Id.* § 203(a)(2)–(3).

247. *See* Nielsen & Samardzija, *supra* note 172, at 536 (detailing an analysis of when compulsory

the damage of patent thickets and holdups.[248] While some suggest that this may not be an efficient solution due to the need for the third party seeking the compulsory license to pay for the costs of the administrative hearing,[249] it may still be a cheaper option than negotiating an unfavorable license agreement or pursuing patent litigation.

Yet, the government has never exercised its march-in rights.[250] And, of course, compulsory licenses are not without their share of problems. Some believe such a blow to the strength of patent rights could "stifle innovation and investment in nanotechnology."[251] But the analysis from Part III suggests that innovation would not be curtailed, as long as the compulsory licenses are limited to foundational patents of broad scope with the highest potential for blocking or holdup. Additionally, empirical work provides little support for the proposition that compulsory licenses would stifle innovation.[252] Thus, it may be appropriate to change U.S. patent policy regarding compulsory licensing and for the government to finally exercise its march-in rights under the Bayh-Dole Act.[253]

The Bayh-Dole Act also gives the federal agency funding a project that gives rise to the patented invention "a nonexclusive, nontransferable, irrevocable, paid-up license to practice or have [any subject invention] practiced for or on behalf of the United States."[254] The terms of such a license seem broad indeed, especially when read in light of the policy and objectives of the Bayh-Dole Act.[255] There is good reason to think that the statutory license granted to the government permits it to allow anyone to practice the invention on behalf of the United States and commercialize the invention in order to "protect the public against nonuse . . . of inventions,"

licensing is appropriate if the patent holder is not utilizing its patent itself); Sabety, *supra* note 37, at 509–10.

248. *See* Merges & Nelson, *supra* note 75, at 865–66, 866 n.118; Nielsen & Samardzija, *supra* note 172, at 539.

249. *See* Sabety, *supra* note 37, at 510–11.

250. *See, e.g.*, Lemley, *supra* note 27, at 628.

251. *See* MILLER ET AL., *supra* note 3, at 80.

252. *See* F.M. Scherer, *The Economics of Compulsory Patent Licensing*, *in* MONOGRAPH SERIES IN FINANCE AND ECONOMICS 85–86 (1977); Richard Levin et al., *Appropriating the Returns from Industrial Research and Development*, 1988 BROOKINGS PAPERS ON ECON. ACTIVITY 783, 804. Both papers conclude that compulsory licenses do not change managers' sentiments regarding patents and research and development spending.

253. Unless U.S. patent policy regarding compulsory licensing changes, we are left with courts and litigation tools, such as the reverse doctrine of equivalents, to find either infringement or no infringement. *See* Merges & Nelson, *supra* note 75, at 865–66, 866 n.118.

254. 35 U.S.C. § 202(c)(4) (2006).

255. *See supra* note 36.

as consistent with the statute's policy.[256] With such authorization in hand, a licensee of the government would be allowed to practice the patent, and any authorized sales of the invention from the government licensee to another company would likely be found to exhaust the patent rights, meaning that the purchaser would not be liable for any infringement of the patent to the publicly funded patentee.[257] This is an attractive solution in the case of upstream foundational patents on nanomaterials, as the sale by the company practicing the invention on behalf of the government would allow the upstream materials to be purchased and used by downstream product manufacturers without the threat of infringement or holdup. This approach would also allow the government to circumvent the procedural aspects of the compulsory license approach under the statutory march-in rights.

The above two approaches under the Bayh-Dole Act are backwards looking. Alternatively, the public funding organization could determine at the outset of any funding venture that the invention is of "exceptional circumstances" and put a restriction on the patent rights of the inventor.[258] This may be most appropriate in "cases where exclusivity is not necessary to bring a patented invention to market."[259] The government agencies funding these projects should look harder at the likely outcomes of their funding and construe the "exceptional circumstances" language as broadly as they need to ensure that the subject invention will be on a path to commercialization, especially in the case of funding that will result in foundational patents.[260]

Thus, the government has the proper powers and resources to achieve its own goal of bringing nanotechnology to commercialization. The government is well positioned to determine appropriate patent pools in terms of validity and antitrust concerns, and has the ability to incentivize

256. 35 U.S.C. § 200.

257. Infringement can only be found when there is no authority to practice a valid patent. The first sale doctrine allows a purchaser of a patented invention from the patent owner or the patent owner's licensee to use or resell the invention without any conditions or controls of the patent owner. *See* 5 CHISUM, *supra* note 117, at § 16.03[2].

258. Sabety, *supra* note 37, at 510–11. The policy and objectives of the Bayh-Dole Act include as follows:

> Each nonprofit organization or small business firm may, within a reasonable time after disclosure . . . elect to retain title to any subject invention: *Provided, however*, That a funding agreement may provide otherwise . . . (ii) in exceptional circumstances when it is determined by the agency that restriction or elimination of the right to retain title to any subject invention will better promote the policy and objectives of this chapter . . . .

35 U.S.C. § 202(a).

259. Sabety, *supra* note 37, at 511.

260. *See* Sabety, *supra* note 37, at 512.

the market players to pool their patents. Alternatively, the Bayh-Dole Act bestows upon the government limited rights that, when construed in a broad fashion, can be very powerful in clearing the nanotechnology patent thicket and eliminating holdup. While the costs of carrying out either of these approaches may be steep, if the government wants to ensure a return on its investment in nanotechnology, these solutions should be reviewed and the difficulties understood now so that the government will be in a position to exercise its rights when the time comes.

V. CONCLUSION

Nanotechnology could be the beginning of an economic and technological revolution. The ability to manipulate materials at the nanoscale and exploit their nanoscale properties will allow various industries to make advances that were not possible before. The U.S. government recognizes that becoming a worldwide leader in nanotechnology is an important goal for the economy, and has willingly funded the NNI and its research efforts. But the uniqueness of the nanotechnology patent landscape is a roadblock on the way to the commercialization of nanotechnology in many industries. Segmented patent rights and broad claims have created a patent thicket that will be difficult and costly for industry players to navigate. These same characteristics open an opportunity for companies seeking to maximize revenues to holdup commercialization by requiring royalties not proportionate to the value of the patents they hold.

While patents are necessary to stimulate innovation throughout nanotechnology and to secure financing for many start-ups, it is not necessary that those patents are afforded strong stature. The characteristics of nanotechnology suggest that innovation will continue in the absence of strong patent rights. Historically, foundational patents of broad scope have been shown to stifle innovation. Thus, affording such patents less strength to help remedy the patent thicket and holdup problems created by the patent landscape and ensure that nanotechnology can continue marching towards commercialization is desirable because innovation will continue despite the weaker patent rights.

The traditional remedies of cross licensing and patent pooling do not seem as though they will be effective in nanotechnology due to the asymmetry of the industry participants and the highly segmented field of patent rights. A few other tools were discussed but also seem to be of limited value. Outside of questioning patent validity in nanotechnology, government sponsored patent pools, as have been used in the past, seem to offer a very good solution assuming that the government is willing to fund analysis of proper pooling techniques for various nanotechnology industries, as well as to determine how to entice all necessary members to participate. Also, the government is in a position to use its rights under the Bayh-Dole Act to threaten compulsory licensing against those members who are unwilling to participate in the patent pools, and in some limited situations, it should exercise those rights to clear the patent thicket and alleviate holdup. Alternatively, the Bayh-Dole Act may simply allow the government to license publicly funded nanotechnology inventions without going through the tedious procedures of march-in rights. These licenses may lead to the exhaustion of patent rights against downstream product manufacturers commercializing the subject invention. The government should expend the resources necessary to study these options, as they may very well be the best way to ensure that nanotechnology can be commercialized efficiently and with competition in the industry, while still providing enough incentive for continued innovation.