How Patents Provide the Foundation of the Market for Inventions

Daniel F. Spulber
Northwestern University
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Abstract

The paper develops a comprehensive framework demonstrating how patents provide the foundation of the market for inventions. Patents support the establishment of the market in several key ways. First, patents provide a system of intellectual property (IP) rights that increases transaction efficiencies and stimulates competition by offering exclusion, transferability, disclosure, certification, standardization, and divisibility. Second, patents provide efficient incentives for invention, innovation, and investment in complementary assets so that the market for inventions is a market for innovative control. Third, patents as intangible real assets promote the financing of invention and innovation. The market foundation role of patents refutes the economically incorrect "rewards" view of patents. The discussion considers how economic benefits of the market for inventions should guide IP policy and antitrust policy.

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* Elinor Hobbs Distinguished Professor of International Business, Department of Strategy, Kellogg School of Management, Northwestern University, 2001 Sheridan Road, Evanston, IL, 60208. E-mail: jems@kellogg.northwestern.edu. I thank Alexei Alexandrov, Justus Baron, Julie Carlson, Richard Epstein, Kirti Gupta, Steve Haber, John Howells, Ron Katznelson, Scott Kieff, Zorina Khan, Mark Lemley, Adam Mossoff, Ben Roin, Carl Shapiro, Ralph Siebert, Henry Smith, Mark Snyder, Richard Taffet, and Heidi Williams for helpful comments. I am grateful to Qualcomm and the Kellogg School of Management for research support. Prepared for presentation at the Inventions and U.S. Patent System Conference, Working Group on Intellectual Property, Innovation, and Prosperity, Hoover Institution, Stanford University, May 19-20, 2014, Stanford, CA.. I thank participants at the Research Roundtable on Software and Business Method Patents, Searle Center on Law, Regulation and Economic Growth, Northwestern University School of Law, April 24-25, 2014, for their helpful comments.

Introduction

The U.S. patent system issued its first patent on July 31, 1790, which was signed by President George Washington.[1] Samuel Hopkins obtained that patent for a process of making potash, an ingredient used in fertilizer.[2] The over 6 million patents issued since then have supported the market development of steamships, automobiles, electric power, electric appliances, aviation, aerospace, telecommunications, mobile communications, computers, the Internet, biotechnology, and nanotechnology. Despite these significant achievements, the U.S. patent system is facing a perfect storm of criticism from academics, politicians, judges, journalists, and industry groups, with calls for abolishing or heavily regulating patents. In this paper, I suggest that the anti-patent storm in part reflects a basic misunderstanding of the purpose of the patent system. A better understanding of the contributions of patents may help calm the anti-patent storm and avoid disrupting the highly successful U.S. system of invention and innovation.

I argue in this paper that patents 'promote the progress of science and useful arts' because they provide the foundation of the market for inventions.[3] I develop a comprehensive economic

[1] http://www.uspto.gov/news/pr/2001/01-33.jsp

[2] http://www.uspto.gov/news/pr/2001/01-33.jsp

[3] The US Constitution offers valuable guidance regarding the purpose patents in granting Congress the power "To promote the Progress of Science and useful Arts, by securing for limited Times to Authors and Inventors the exclusive Right to their respective Writings and Discoveries." U.S. CONST. art 1 § 8, cl. 8.

framework for the study of patents that extends work I have done on market microstructure, the theory of the firm, invention, and innovation (Spulber, 1999, 2009a, 2014). Applying this framework, I demonstrate that patents support the market for inventions in several important ways: (1) by increasing transaction efficiencies and stimulating competition; (2) by allowing owners to control how inventions are turned into innovations and guiding incentives for invention and innovation; and (3) by promoting the financing of invention and innovation.[4] I show that the market foundation role of patents has important implications for antitrust and public policy toward intellectual property (IP).

Yet, for many academics, the patent system is a "failure" (Bessen and Meurer, 2008), in a "crisis" (Burk and Lemley, 2009), and a "major wound" that should be abolished (Boldrin and Levin, 2013, p. 18). The press tends to agree: "[a]busive and frivolous lawsuits brought by holders of patents are costing the American economy billions of dollars."[5] Antitrust policy makers seeking "a proper balance between exclusivity and competition" argue that "[i]nvalid or overbroad patents disrupt that balance by discouraging follow-on innovation, preventing competition, and raising prices through unnecessary licensing and litigation" (Federal Trade Commission, 2011, p. 1). The Supreme Court in a series of opinions (*Bilski*, *Prometheus*,

[4] I discuss the market for inventions and examine some of the implications of transaction costs and other market frictions for invention and innovation in Spulber (2014).

[5] Editorial Board, 2014, "Abusive and Frivolous Patent Suits," *The New York Times*, April 6, http://www.nytimes.com/2014/04/07/opinion/abusive-and-frivolous-patent-suits.html?_r=0 Accessed April 16, 2014.

Myriad) has ruled claims for a wide range of subject matters as patent-ineligible.[6] Commentators have noted the "hostility to patents" by the Executive Branch.[7] Congress is in the midst of

[6] Lamenting this state of events, Judge Moore in *CLS v. Alice* United States Court of Appeals, Federal Circuit, Dissenting-in-part opinion filed by MOORE, Circuit Judge, in which RADER, Chief Judge, and LINN and O'MALLEY, Circuit Judges, join, states "I am concerned that the current interpretation of § 101, and in particular the abstract idea exception, is causing a free fall in the patent system. The Supreme Court has taken a number of our recent decisions and, in each instance, concluded that the claims at issue were not patent-eligible. *See Bilski, Prometheus, Myriad* (under consideration). Today, several of my colleagues would take that precedent significantly further, lumping together the asserted method, media, and system claims, and holding that they are all patent-ineligible under § 101." http://www2.bloomberglaw.com/public/desktop/document/CLS_Bank_Intl_v_Alice_Corp_Pty_Ltd_717_F3d_1269_106_USPQ2d_1696_2/1, Accessed January 30, 2014.

[7] On concerns about Executive Branch opposition to patents, see Kevin Noonan, 2014. "Thoughts on the USPTO's Patent Eligibility Guidelines (and What to Do About Them)," March 18, Patent Doc: Biotech an Pharma Patent Law & News Blog, http://www.patentdocs.org/2014/03/thoughts-on-the-usptos-patent-eligibility-guidelines-and-what-to-do-about-them.html, Accessed April 16, 2014. See also Lisa L. Mueller, "The Thorny Problem of Patentable Eligible Subject Matter: An Introduction," http://www.natlawreview.com/article/thorny-problem-patentable-eligible-subject-matter-introduction, Accessed April 16, 2014.

extensive bipartisan patent reform efforts.[8] According to industry lobbyists such as the Electronic Frontier Foundation "[w]e happen to be at a special point in time when every branch of government is itching for patent reform."[9]

I demonstrate that contrary to these assertions, patents create economic benefits because the market for inventions generates efficient incentives for invention and innovation. This is important because market for inventions is vast. The market for inventions includes disembodied inventions in the form of licensing, cross licensing, assignments, and contractual R&D. The market for inventions also includes technologies embodied in goods and services, production processes, transaction techniques, and firms themselves.[10] The market for inventions further includes financing of invention and innovation through entrepreneurial and corporate finance.

First, I show that key features of the patent system – exclusion, transferability, disclosure, certification, standardization, and divisibility – increase *transaction efficiencies and stimulate competition* in the market for inventions. These properties of patents reduce transaction costs associated with transferring, licensing, cross-licensing, combining, implementing, and

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[8] Kristal High, 2014, Patent Reform Movement Shines a Light on Economic Development Opportunities, March 28, *Huffinton Post*, http://www.huffingtonpost.com/kristal-high/patent-reform-movement-sh_b_5048578.html, Accessed April 16, 2014.

[9] Adi Kamdar, 2014, "The Patent Reform We Need to See from the Senate," Electronic Frontier Foundation, March 31, https://www.eff.org/deeplinks/2014/03/patent-reform-we-need-see-senate, Accessed April 16, 2014.

[10] I develop a formal model of the market for inventions with endogenous R&D and entry of inventors and producers (Spulber, 2013a, 2013b). On empirical studies of the market for inventions see Arora et al. (2001a, 2001b).

developing inventions. Patents give owners rights to exclude others from making, using, or selling their inventions.[11] Patents help convert inventions into transferable assets so that inventors and adopters can transact more efficiently in the market for inventions. Patents promote disclosure of inventions, which reduces costs of search and bargaining in the market for inventions. Patents provide certification of technologies, which decreases information asymmetry in the market for inventions. Patents provide standardization in IP, which reduces the costs of contracting in the market for inventions. Finally, patents allow greater divisibility of technology, which promotes modularity and increases gains from trade in the market for inventions. Patents thus generate economic benefits that are based on more efficient transactions and greater competition in the market for inventions.

Second, I argue that the market for inventions is a *market for innovative control*. Patent owners not only obtain residual returns by commercializing their inventions but also choose how inventions will be made, used, or sold. Patents thus are transferable assets representing *investment projects with random outcomes*. The market for inventions helps determine the value of inventions, selects the best inventions, and allocates inventions to the highest value users. Because it is a market for innovative control, the market for inventions generates efficient incentives for invention, innovation, and investment in complementary assets. The market for inventions provides incentives for the efficient organization of firms and industries in terms of the extent of vertical integration of R&D and manufacturing. Efficiencies in the market for innovative control help explain the market returns to patent ownership.

[11] Alchian (2008) points out that the three aspects of property rights are exclusion of access, control over how the asset will be used, and transfer of the asset to others.

Third, I emphasize that patents facilitate the *financial separation* of inventions from their inventors, helping inventors obtain financing.[12] By serving as *intangible real assets*, patents are useful for contracts that finance invention, as indicated by the use of licensing or transfer options for companies funding university research. Entrepreneurs report that patents can be important in securing financing for startups and establishment of firms.[13] Patents also are important for corporate finance and appear as intangible real assets in the balance sheets of corporations. Patents affect the value of corporations in two main ways.[14] Patents that are "assets in place" affect the firm's earnings either through licensing royalties or through own-use of the technology as a productive input. Patents that offer "growth opportunities" affect the firm's expected value because they indicate the potential to invest in innovation based on the firm's IP or to invest in invention of related technology. Financial contracts and the capital structure of firms help provide incentives for invention and innovation.

Patents are *forward-looking*: they perform most of their economic functions in the market for inventions after they are granted. The market foundation role of patents stands in stark contrast to the common view that patents provide "rewards" for inventors. The "rewards" view is *backward-looking*; patents complete most of their economic functions at the time they are granted. The "rewards" view of patents is highly misleading for public policy because it does not accurately describe public and private institutions. Markets, not government agencies, determine

[12] See Myers (1999, 2000) on financial separation and entrepreneurship. See Spulber (2009a, 2009b) on financial separation in the theory of the firm and Spulber (2014) on financial separation in the theory of the innovative entrepreneur.

[13] See particularly the major study by Graham et al. (2014).

[14] This follows Myers (1977) distinction between "assets in place" and "growth opportunities."

what rewards inventors and innovators receive and market participants provide those rewards. The "rewards" view considers patents as sources of residual returns for IP owners rather without considering that ownership provides the basis for innovative control. Based on the "rewards" view, some researchers recommend weakening patents through antitrust, limits on litigation, compulsory licensing, government ownership, price controls, taxes, and subsidies.[15] These regulatory approaches would stifle or eliminate the economic benefits that result from markets for invention.

The market foundation role of patents offers insights into public policy towards IP. With patent protections for IP, the market for inventions determines the market value of inventions and the returns to invention, innovation, and complementary inventions. IP policy should maintain the property rights system because of its benefits for competition and transaction efficiencies. This implies maintaining the key features of the patent system: exclusion, transferability, disclosure, certification, standardization, and divisibility. In addition, to support the market for innovative control and the financing of invention and innovation, patents should have sufficient scope to provide IP protections for development of inventions and innovations. Weakening patent rights would reduce transaction efficiencies and competition, would distort incentives and guidance in the market for innovative control, and would reduce incentives to finance invention, commercialization, and innovation. Public policy makers should not attempt to determine rewards for inventors because governments lack the vast amounts of information dispersed in the market place, as Friedrich Hayek understood.[16]

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[15] See Roin (2014) for an overview and discussion of the literature based on the "rewards" view of patents. See for example Stiglitz (2008) and Shapiro (2008).

[16] See Hayek (1945, 1975).

The market foundation role of patents implies that antitrust policy should support rather than weaken IP protections. When there is a market for inventions, *competitive pressures* both among inventors and among producers who apply inventions increase incentives to invent and to innovate (Spulber, 2013a, 2013b). On the supply-side of the market for inventions, competitive pressures increase incentives to invent and decrease royalties for inventions. On the demand-side of the market for inventions, competition drives incentives of adopters to purchase or license discoveries, to introduce economic innovations based on those discoveries, and to invest in complementary activities. Weakening patents reduces incentives to participate in the market for inventions, leading inventors to protect their IP through other means such as trade secrets, research and development (R&D) alliances, and vertical integration. In the absence of a market for inventions, competitive pressures tend to reduce incentives to invent and to innovate.

There are a number of important prior works that are related to the market foundation role of patents discussed here. Judge Giles Rich in a series of writings emphasizes the importance of patents for innovation. Rich (1972, p. 26) observes "A time-limited exclusive right to subject matter which was neither known, nor obvious from what was known, *takes nothing from the public which it had before*. As a necessary corollary, the disclosure in a valid patent gives to the public knowledge it did not possess, actually or potentially, and thereby makes for progress," (emphasis in original). Harold Demsetz (1969, p. 14) points that the problem of indivisibility of information is best handled by "a private property system that reduces the cost of contracting and raises the cost of free-loading while, at the same time, it provides incentives and guidance for investment in producing information."[17]

[17] For a more skeptical view of the market for ideas, see Gans and Stern (2010).

An important contribution by Edmund Kitch (1977) argues that the function of patents is to help attract resources to innovative "prospects."[18] Kitch (1977) contrasts his "prospects" view of the patent system with the "rewards" view. Patents are "prospects" because a patent generally discloses an invention *before* it is fully developed and covers *potential* innovations based on that invention. Kitch (1977) correctly points out that patents allow owners to coordinate the search for technological and market improvements, to invest in innovation based on the invention, to invest in distribution and marketing of the invention, to contract more readily with providers of complementary information, resources, and financing, to avoid duplicating investment of other patent holders, and to exercise control over the technology. The present work extends Kitch's insightful analysis and offers an economic framework for understanding the role of patents in the market for inventions.

F. Scott Kieff's (2001) valuable discussion of patents finds that "the treatment of patents as property rights is necessary to facilitate investment in the complex, costly, and risky commercialization activities required to turn nascent inventions into new goods and services. Furthermore, property treatment is equally necessary to help society decide which inventive activities are worth protecting in the first instance," (p. 703). Kieff (2001) critiques the "rewards" view of patents, pointing out that reward systems do not account for innovative activities after

[18] Kitch (1977, 266) states "the view of the patent system offered here conceives of the process of technological innovation as one in which resources are brought to bear upon an array of prospects, each with its own associated sets of probabilities of costs and returns. By a prospect I mean a particular opportunity to develop a known technological possibility." See also Barzel (1968).

inventions have been made.[19] Kieff (2001, p. 710) highlights both coordination and investment in commercialization: "The patent right to exclude competitors who have not shared in bearing these initial costs provides incentives for the holder of the invention and the other players in this market to come together and incur all costs necessary to facilitate commercialization of the patented invention." The analysis of the market for inventions presented here encompasses the coordination and commercialization aspects of patents discussed by Kieff.

Richard Epstein (2010, p. 458) emphasizes that exclusivity "seeks to maximize the gains from both the creation and dissemination of protected information." Epstein demonstrates the fundamental connections between tangible and intangible property. The limited term of exclusion for patents allows the application of rules concerning exclusion, use and disposition in real property, which also is subject to limitations such as antitrust law and the law of private and public necessity. Epstein (2010, p. 459) explains that the evolution of property rights in inventions (and writings) are "a conscious extension of the classical liberal conception of property that is associated with such writers as John Locke, William Blackstone, and Adam Smith."

Henry Smith (2009) emphasizes the modularity of intellectual property: "The traditional view of markets has a strongly modular flavor, and one role of modular property is to support markets." Smith notes that a modular system involves greater interaction within modules than across modules. IP rights allow the establishment of boundaries by exclusion of others, which allows asset partitioning, greater interaction within modules, usage of local information, and grouping of complementary activities. IP rights also allow interaction and exchange of

[19] See also Smith (2007), Spulber (2011) and Daily and Kieff (2013).

information across modular boundaries. Smith (2002) emphasizes the reduction of transaction costs by exclusivity in property.

The paper is organized as follows. Section I examines how patents improve transaction efficiencies and competition in the market for inventions. Section II considers how the market for inventions is a market for innovative control that provides incentives for invention and innovation, promotes selection of the best inventions, allocates inventions efficiently, gains from trade, and investment in complementary assets. Section III considers how patents are useful for financing invention and innovation. Sections IV and V discuss implications for IP policy and antitrust policy. Section VI concludes the discussion.

I. Transaction Efficiencies and Competition in the Market for Inventions

Patents increase the efficiency of transactions and intensify competition in the market for inventions. This is because the patent system offers a sophisticated property rights framework that combines exclusion with other mechanisms that facilitate exchange. Patents are forward looking because property rights support market transactions that take place after the patent is granted. The discussion in this section identifies some key elements of the patent system that are fundamental for market exchange.

A. Exclusion

The United States Patent and Trademark Office (USPTO) defines a *patent* as "an intellectual property right granted by the Government of the United States of America to an inventor 'to exclude others from making, using, offering for sale, or selling the invention throughout the United States or importing the invention into the United States' for a limited time

in exchange for public disclosure of the invention when the patent is granted." Although the present discussion applies to IP generally, my focus is on *utility patents* that "may be granted to anyone who invents or discovers any new and useful process, machine, article of manufacture, or composition of matter, or any new and useful improvement thereof."[20] Inventions include commercial, scientific, and technological discoveries.

The right to exclude provides property rights needed to establish a market for inventions. Patents are forward looking because transactions based on patents such as licensing and assignments generally take place after the patent is granted. Patents protect investment-backed expectations; inventors usually invest in developing and commercializing their inventions after the patent is granted. Patent owners invest in innovation and complementary assets after patents are granted. An inventor's returns, if any are ever obtained, are based on the inventor's commercialization efforts and the market value of the invention.

Patents also are forward looking because the market value of inventions often is determined after the patent is granted. Exclusivity gives inventors have the opportunity to obtain the market value of their patents. The value of the inventor's asset is determined after the fact and depends on the demand for the invention and the supply of competing technologies. The price of inventions can be explicit for disembodied inventions. The prices of inventions can be implicit for inventions embodied in products, production processes, transaction methods, and

[20] The USPTO also grants design patents "to anyone who invents a new, original, and ornamental design for an article of manufacture" and grants plant patents "to anyone who invents or discovers and asexually reproduces any distinct and new variety of plant." See USPTO, http://www.uspto.gov/patents/index.jsp, accessed January 18, 2014.

firms. The prices of inventions change continually in response to variations in demand for inventions and the supply of alternative technologies.

Patents are forward looking because after the patent is granted, the patent owner invests in enforcement by defending challenges of validity, monitoring infringement, and seeking injunctions and damages for infringement. According to the USPTO, "it is up to the patent holder to enforce his or her own rights if the USPTO does grant a patent."[21] The patent system, including provides a legal framework for determining infringement and damages. Legal battles over infringement are a natural aspect of the patent system and do not in themselves indicate problems with patents.

Indeed, the legal costs of the patent system are part of the costs of operating a system of property rights. The number of patent law suits constitutes a tiny fraction of the number of active patents. Patent lawsuits are less than two tenths of one percent each year from 1920 to 2010 (Katznelson, 2014). Patents are only about one percent or less of all civil law suits in U.S. District Courts for almost every year since the Second World War (Katznelson, 2014).[22] Many studies critical of the patent system tend to emphasize litigation costs without comparing these costs to the economic benefits of the patent system; see for example Bessen and Meurer (2008) and Burk and Lemley (2009).

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[21] http://www.uspto.gov/patents/resources/types/utility.jsp#heading-1, Accessed January 29, 2014.

[22] This does not include the years since the America Invents Act, which increased the number of suits by separating defendants. There was a brief spike approaching 1.5% during the 1960s (Katznelson, 2014).

Patents generate economic benefits because appropriability of the returns to invention and innovation is critical to the development of the market for inventions. In university licensing, de Rassenfosse et al. (2014) find empirical support for the appropriability effect by showing that negotiations involving a granted patent instead of a pending patent are more likely to be successful in fields with more effective IP protections such as biotech, chemicals, medical equipment, and pharmaceuticals. Branstetter et al. (2006) demonstrate empirically that strengthening patent rights increases technology transfers among U. S. multinationals.

Economic historians have documented extensively the importance of the patent system in the establishment of the market for inventions, see Khan and Sokoloff (2001) and Lamoreaux and Sokoloff (2003). Khan's (2005, p. 314) study of the U.S. patent system from 1790 to 1920 finds that "[s]ecure property rights in patented inventions helped to create tradeable assets." During this period, the U.S. patent system "stood out as conduit for creativity and achievement among otherwise disadvantaged groups" and "comprised a key institution in the progress of technology" (Khan, 2005, p. 221). Khan (2013b) examines the international market for inventions from 1790 to 1930 and shows that international trade in patented inventions responded to incentives from IP protections. Khan finds that greater protections for IP rights encouraged the formation of global markets for inventions.

An indication of the benefits of IP protection is that companies conducting in-house R&D choose to obtain patents for their inventions. For example, the ten leading patenters in the US in 2013 were corporations conducting in-house R&D: IBM (6,809), Samsung (4,675), Canon (3,825), Sony (3,098), Microsoft (2,660), Panasonic (2,601), Toshiba (2,416), Hon Hai (2,279), Qualcomm (2,103), and LG Electronics (1,947). [23] Extensive and growing patenting by

[23] Barinka (2014).

universities and public research organizations also provides evidence of the benefits offered by the patent system.[24]

The growing volume of patent applications provides some evidence that the patent system is an effective institution. Because applying for patents is costly, this provides some indication of inventors' demand for patent protection. The USPTO receives over 500,000 applications per year.[25] However, increases in the number of patents or the number of citations need not increase innovation and productivity, a phenomenon known as the "patent puzzle." Boldrin and Levine (2008) conclude based on a literature survey that "strengthening the patent regime increases patenting!" However, evaluating the market value of patents for both disembodied and embodied inventions provides a better indication of the connection between patents and innovation.

B. Transferability

Transferability of patent usage and ownership contributes significantly to the establishment and operation of the market for inventions. Because they are transaction institutions, markets require legal transferability of products. John R. Commons (1931, p. 648) states "[t]ransactions are the means, under operation of law and custom, of acquiring and alienating legal control of commodities, or legal control of the labor and management that will produce and deliver or exchange the commodities and services, forward to the ultimate

[24] The World Intellectual Property Organization (2011) observes a significant increasing in patent applications by universities and public research organizations.

[25] http://www.uspto.gov/patents/resources/types/utility.jsp#heading-1, Accessed January 29, 2014.

consumers." Technology transfers that occur through infringement, imitation, and spillovers are not market transactions. Patent owners often license patents after infringement occurs; which can convert such technology transfers into market transactions. Kieff (2001) emphasizes the importance of patents as property rights for commercialization and identifies problems with liability rules.

Transactions involving disembodied technology include selling patents, licensing patents, and cross-licensing patents. Patent owners may bundle knowledge transfers with patent licensing or transfers, particularly when patent owners are inventors who have tacit knowledge. The returns to selling the bundle cover the market value of the IP and the costs to the inventor of codifying and communicating tacit knowledge (Spulber, 2012). The market for disembodied inventions includes transfers of knowledge, discoveries, ideas, and technologies that are protected by IP other than patents, including trademarks, copyright, and trade secrets. The market for inventions also includes contractual R&D and R&D consortia.[26] R&D outsourcing contracts and R&D partnership contracts specify ownership of the inventions created by the project. Employment contracts specify who owns inventions created by employees. Contracts for education and training specify ownership of information contained in courses and instruction materials.

[26] On empirical studies of the market for inventions, see Arora et al. (2001a, 2001b), Gambardella et al. (2007), Gans et al. (2008), Arora and Gambardella (2010), Serrano (2010), and Galasso et al. (2013). See also the discussions in Kamiyama et al. (2006), Athreye and Cantwell (2007), Troy and Werle (2008), Arora and Gambardella (2010), and Gans and Stern (2010).

The market for inventions also includes goods and services that embody inventions, products manufactured using inventions, and transactions techniques that apply business method inventions. Patents often provide IP protections for inventions embodied in products, production processes and transaction techniques. The market for inventions includes mergers and acquisitions (M&A) involving companies that own or embody inventions. M&A involves the purchase of a firm's assets including their patent portfolios.

Markets are transaction institutions that are created and managed by individuals and firms (Spulber, 1999, 2009a, 2014). Markets are endogenous to the economy and involve formal and informal rules of exchange that can be characterized as "market microstructure" (Spulber, 1999). Firms that create markets choose profit-maximizing market designs. Firms generate and operate a wide variety of physical and virtual market places such as stores, websites, intermediaries, and auctions. The market for inventions involves these types of institutions, just as do markets for other types of goods and services and financial assets.

The market for inventions includes direct exchange between inventors and adopters of technology and intermediated exchange through a wide variety of market makers, dealers, brokers, insurers, and other specialists. Firms create and operate markets through intermediation, price adjustment, marketing, sales, communication and other coordination mechanisms (Spulber, 1999, 2014). Because markets are endogenous, their institutional features depend on the decisions of market-making firms, the characteristics of buyers and sellers that participate in the market, and the types of goods and services that are exchanged. Market institutions can be efficient for the task at hand without necessarily resembling financial commodity markets. Firms create and operate transaction institutions in the market for inventions.

C. Disclosure

Disclosure often is portrayed as a quid pro quo: the patentee provides disclosure of the invention in return for the patent grant. However, disclosure has value to inventors and adopters as a foundation for market transactions. Disclosure provides a description of the invention, the list of claims and other information in the patent are useful for transactions. It is not necessary for buyers and sellers to spell out all this information every time a transaction occurs. This reduces the costs of licensing and technology transfer contracts. Patents provide transaction efficiencies in a manner that is similar to other forms of ownership registration including securities, real estate, and motor vehicles.[27]

Disclosure reduces the costs to potential adopters of determining what technologies are available for licensing or transfer and what types of prior work has been done. This can reduce the costs of innovation for potential adopters. Disclosure also reduces the costs to other inventors who can learn about prior art and avoid duplicating past research. Inventors also can benefit by extending and improving on existing inventions. Disclosure is also useful for potential adopters to reduce their risk of infringement.

Disclosure also increases transaction efficiencies by reducing search costs in the market for inventions. The USPTO provides a centralized searchable data base for patents. Potential adopters can reduce their costs of obtaining technology by finding out about what patented technologies are available. Inventors also benefit from lower search costs because disclosure reduces their costs of publicizing their inventions to potential adopters. For university inventions,

[27] Patent ownership also is comparable to incorporation of companies, which provides information about the name, purpose and location of the company.

Elfenbein (2007, p. 691) finds that "although a majority of technologies are licensed prior to the receipt of a patent, a patent more than doubles the likelihood of finding a license partner"

Disclosure to the USPTO also mitigates adverse selection in bargaining between inventors and adopters. Adverse selection in bargaining can result in the failure of a buyer and a seller to come to an agreement even though the transaction would offer gains from trade. When the quality of the seller's good is observable to the buyer but not to the seller, the seller's offer may not be sufficient to compensate the buyer. Disclosure increases the information about inventions available to potential adopters, thus reducing asymmetry of information in negotiations between inventors and adopters.

Kieff (2001, 2003) argues that inventors have incentives to disclose their inventions accurately so as to increase the likelihood that their patent will be valid if challenged in court. Kieff (2003) points out that disclosure reduces social costs by providing information about property rights, so that registration in itself generates transaction efficiencies. Kieff (2001) emphasizes that the patent system promotes commercialization through incentives for accurate disclosure. Hegde and Luo (2013) find that information disclosure through patent publications generates transaction efficiencies in the market for inventions and accelerates commercialization of inventions.

D. Certification

The USPTO performs a variety of certification tasks that reduce transactions costs in the market for inventions. These tasks include patent review that determines whether the patent satisfies various criteria that determines whether the invention is useful, novel and non-obvious. The USPTO provides a recognized method of screening and certification that allows market

participants to avoid duplicating theses costs. The certification role offered by the USPTO and the courts provide generic information that supplements the important certification contributions of specialized market intermediaries.

The USPTO's patent review alleviates adverse selection in the market for inventions by certifying the disclosure of information about the invention. This reduces the potential for the "lemons" problem where bad inventions drive out good inventions. The certification system is accompanied by *ex post* review in the courts that determines not only the validity of the patents but also implicitly provides a check on the patent system itself. The certification system also is subject to *ex post* review in the market for inventions itself. Market transactions provide indications of the performance of the certification system. Simply having a patent does not guarantee that the patent has market value, indeed many patents do not have market value. The fact that many patents have value provides an indication of the service provided by the USPTO certification system.

Thus, licensing of patented inventions, patent transfers, and the production of goods and services that embody patented inventions provide evidence of the market value of the USPTO certification system. This serves to refute the assertions of some critics that the patent system creates "bad patents." A number of critics suggest that the USPTO's examination processes have generated patents that are invalid in terms of usefulness, novelty or non-obviousness (Lemley, 2001, Thomas, 2002, Jaffee and Lerner, 2004, Lemley and Moore, 2004). Katznelson (2007) demonstrates that various studies purporting USPTO standards to be inferior to agencies abroad are based on incorrect statistical analysis. Katznelson (2007) critiques statistical methods used by Martinez and Guellec (2004) and Jensen et al. (2006). Katznelson (2007, p. 29) observes that

"even accurate patent grant rate comparisons among national patent offices are of little probative value and should not be used as indicators of examination rigor or patentability standards."

Some critics of the patent system argue that particular types of inventions generate "bad patents." For example, Merges (1999) objects to patenting of software and business method inventions because such technologies were formerly "impossible" to patent.[28] As I argue elsewhere (Spulber, 2011), business method inventions reflect commercial discoveries and should not be treated differently from traditionally defined scientific and technological discoveries. Critics of these types of inventions reflect familiar biases against entrepreneurs and market transactions. There is evidence that software and business method patents are if anything higher in quality than other types of inventions (Allison and Tiller, 2003).

Potential adopters have greater information about inventions than might otherwise be disclosed in transactions involving trade secrets. One type of efficiency loss from adverse selection known as the "lemons problem" occurs if lower-quality goods drive higher-quality inventions from the market. This can occur in principle when buyer willingness to pay depends on the expected value of a good. Suppliers of goods that are better than the expected value will exit the market and suppliers of goods that are worse than the expected value will stay in the market, possibly leading to the collapse of the market entirely. Economic analysis shows that this problem can be alleviated by intermediaries that invest in certifying the quality of goods.[29]

[28] Merges (1999) combines a discussion of the USPTO patent examination process with a presumption that software and business method inventions will lead to bad patents, although these are entirely different questions.

[29] See Biglaiser (1993), Biglaiser and Friedman (1994, 1999), and Spulber (1996, 1999).

Certification also reduces transaction costs by determining the identity of the initial patent owner. The US patent system traditionally granted a patent to the inventor that was the first to invent, which required an initial determination of the identity of the first inventor. Under the America Invents Act, the patent is granted to the first to file.[30] Although there are costs and benefits associated with either system, there are benefits to determination of the initial assignment. This reduces the costs of search in the market place by specifying the assignment of property rights.

E. Standardization

Standardization is an important feature of the patent system that has not gotten sufficient attention. Although each invention is different, patents have consistent features. Patents are standardized documents with an application number, a bar code, an application date, a date of the grant, names of inventors, names of assignees, a title, an abstract, citations to prior patents, and formal specification of claims. Patents are standardized in terms of duration, which is generally twenty years from the time the application was filed. The patent application procedure and examination process are standardized.[31] There is a complex set of rules that apply to all patent

[30] Keiff (2001) suggests that a rush to file under the first-to-file rule can lead to inadequate disclosure, resulting in patents being more likely to be found invalid and reducing incentives for commercialization.

[31] See the *Manual of Patent Examining Procedure* (MPEP), Ninth Edition, March 2014, USPTO, http://www.uspto.gov/web/offices/pac/mpep/index.html, Accessed April 10, 2014.

applications and patent grants.[32] In addition to these rules, there are standardized legal procedures for patent owners seeking injunctions and damages for infringement.

The patent system provides a set of rules governing licensing and transfer of ownership.[33] According to the USPTO, an assignment must include "all of the bundle of rights that are inherent in the right, title and interest in the patent or patent application."[34] A patent licensing agreement "transfers a bundle of rights which is less than the entire ownership interest, e.g., rights that may be limited as to time, geographical area, or field of use." The USPTO maintains public records on assignments.

The patent system offers a standard vocabulary that is common usage in market transactions. Patent numbering and public records of patents and applications offers a highly convenient system for asserting IP; it is sufficient for a company to state the patent number or application number on a product or its packaging. Under the America Invents Act, companies have the option of virtual marking by listing a website with the patent information. This lowers transaction costs by separating patent marking from product manufacturing and distribution (McCaffrey, 2011).

All of this standardization reduces transaction costs in the market for inventions. Standardization of products is an essential aspect of market efficiency. Standardization allows buyers and sellers to focus their attention on the idiosyncratic features of the transaction at hand Standardization allows for economies of scale in transactions. Also, standardization allows

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[32] The United States Code Title 35 – Patents sets for the laws governing patents, http://www.uspto.gov/web/offices/pac/mpep/consolidated_laws.pdf, Accessed April 10, 2014.

[33] http://www.uspto.gov/web/offices/pac/mpep/s301.html, Accessed April 10, 2014.

[34] Id.

buyers and sellers to make comparisons with other transactions, thus facilitating competition. Standardization of vocabulary lowers the costs of communication and negotiation.

In the market for inventions, standardization in patents simplifies licensing contracts, technology transfer agreements, and other transactions. The patent document is part of the agreement and the technology does not have to be fully described each time a transaction occurs. Prices and other contract terms adjust to reflect the unique features of the technology itself and the purposes of the agreement between the buyer and seller. Standardization offered by patents facilitates financial transactions including the financing of invention and innovation, entrepreneurial finance, and corporate finance.

Standardization in patents reduces transaction costs associated with the development and adoption of technology standards. Patents provide a means for IP owners of conveying information to standards organizations. Companies with patents that read on a standard can readily declare patents “essential” to a standard by communicating the patent numbers to the organizations. Companies that develop new technologies related to existing standards can obtain patents for those standards and report those to standards organizations. Companies seeking to adopt technology standards can determine what IP may be relevant to the standard by observing what patents declared “essential.” Patents serve as standard building blocks for technology standards.

Conversely, technology standards are useful to patent examiners in determining the novelty of inventions. Willingmyre (2012, p. 10) observes that “Standards, publicly available draft standards, and publicly available discussions during standards setting can be a rich source of information about ‘prior art.’” Willingmyre (2012, p. 16) points out that the “public pair”

database at the USPTO contains useful references to technology standards and standard setting meetings.

F. Divisibility

Patents are useful for the divisibility of technology into discrete units. Although there is considerable debate over whether patents should be broader or narrower, patents serve to define boundaries between inventions. This has important benefits for transactions in the market for inventions. Modularity of technologies enhances competition by allowing component level rivalries without the need to recreate entire systems.

Patents necessarily impose boundaries on inventions as spelled out in patent claims and the specifics of the technological descriptions. There are numerous transaction advantages of the divisibility. The most important benefit of discreteness is that buyers and sellers can enter more easily into transactions that only involve a specific technology. The technology can meet the particular purposes of the adopter without their having to purchase a host of costly technologies that they might not need.

Patents as discrete inventions are the building blocks for collections of inventions. Patents can be combined to form a patent portfolio. Firms can assemble a portfolio of patents with different technologies to meet their production needs. Buyers can license or purchase patents from different patent owners. Patent bundling offers transaction efficiencies by providing convenience to buyers and sellers. Because they represent discrete inventions, the particular needs of buyers and sellers can be satisfied by choosing the best combination of patents.

By offering divisibility, patents promote efficiency in the organization of firms and industries. A firm need not conduct R&D on all the technologies necessary to produce a product

or service. Instead, firms can specialize in a particular type of R&D. Then, buyers can assemble the technologies they need through the market for inventions. In this way, patents help foster *modularity* of technologies, which allows the separation and combination of different parts of a technology platform.

Modularity of technologies generates efficiencies from specialization and division of labor. Different companies can focus on invention, innovation and manufacturing. Also, companies can focus on different types of R&D. For example, in the computer industry different firms can focus on R&D in software, microprocessors, memory, and screens. This type of specialization improves inventors' knowledge and experience in comparison with what occur if firms would need to be proficient in all technologies needed to produce a particular product.

Because patents offer divisibility, as well as exclusivity and transferability, companies can engage in specialized R&D and exchange technologies in the market for inventions. This allows a division of labor in invention, innovation, and manufacturing. Specialization allows companies to take advantage of economies of scale and other types of efficiencies in invention, innovation, and manufacturing. Market exchange of technologies generates gains from trade by selection of the best inventions and wider usage of the best inventions (Spulber, 2008, 2010). Patents offer technological divisibility to the market for inventions that increases gains from trade.

II. The Market for Innovative Control

Because of patent protections for IP, the market for inventions is a market for innovative control. The residual returns from licensing, selling, or using patented inventions are only part of patent ownership. A patent owner can exercise residual rights of control because they can

exclude others from making, using or selling the invention.[35] The market for innovative control provides incentives for efficient investments in invention, innovation, and complementary assets. This is related to the way that ownership of corporate securities is the basis of a market for corporate control. Securities facilitate the separation of ownership and control and yield other transaction efficiencies (Manne, 1965, Spulber, 2009b).

A. Invention and Commercialization

The market for innovative control provides incentives for inventors to produce inventions that are desirable for consumers and producers. As a result of competition among inventions, the market for inventions helps to determine the best inventions for particular needs of consumers and firms. Competition among potential adopters also helps the market for inventions allocate inventions to the highest value users. The market for inventions determines the relative returns to invention, commercialization, and innovation.

The market for inventive control thus provides valuable information and guidance to inventors and adopters. What matters are inventions, which are the *outputs* of R&D, rather than inventive efforts, which are the *inputs* of R&D. The point is not simply to reward any and all inventive efforts, but rather to provide incentives that direct inventive efforts based on the anticipated market value of inventions and innovations. Simply subsidizing invention or rewarding inventive efforts could produce more inventive efforts but not necessarily better inventions. Government subsidies or rewards for invention in the absence of IP protections also

[35] The patent owner does not grant rights of control because the patent owner is subject to whatever legal and regulatory restrictions might apply. The patent owner thus exercises residual rights of control in commercializing and developing the patented invention.

would not provide incentives for commercialization of inventions, which is essential for diffusion of technology and innovation.

The market for innovative control provides important economic benefits. The interaction of the demand and supply of inventions determines the market value of inventions. Inventors compete to supply producers with inventions and producers compete to obtain inventions or develop their own inventions (Spulber, 2013a, 2013b). The market value of an invention reflects competition from both substitute and complementary inventions on the supply side of the market for inventions. The market value of inventions depends on the stock of inventions and anticipation of future discoveries that may enhance the demand for particular inventions or render those inventions obsolete. The market value of an invention also reflects the returns to applying inventions obtained by adopters on the demand side of the market for inventions.

The patent provides IP protections for additional development of the invention and embodiment of the invention in some innovations covered by the claims. This is consistent with Kitch (1977) who explains that patents are "prospects" analogous to mineral rights that have yet to be fully developed. To formalize these concepts, I characterize a patented invention as an intangible real asset whose market value is random. The randomness in the value of the asset is due to randomness in the outcomes of the development process, in the costs of the development process, and in market valuations of the outcomes of R&D. The market value of the asset also can depend on the extent of the claims in the patent.[36]

[36] Although the emphasis here is on development of the invention, the framework is sufficiently general to include randomness in the legal and regulatory process. This could include randomness in the legal patent validity as discussed in Lemley and Shapiro (2005).

The market value of the asset can be represented by a random variable *V* that is distributed according to a probability distribution *F(V)*. The random variable *V* can be viewed as an *investment project*. The probability distribution of the value of the asset *F(V)* can be generalized in various ways. The patent owner can choose among various investment projects with random outcomes, so that the distribution of the value of the patent depends on the choice of projects. The patent owner can invest in development and commercialization, so that the distribution of the market value of the patent depends on the level of investment.

With patent protections, inventors' expected returns depend on the market value of their inventions. This provides incentives to inventors to invest in R&D and commercialization of inventions that depend on the supply of and demand for different types of inventions. The expected market value of inventions provides guidance to inventors for efficient investment in R&D. Efficient levels of investment in R&D reflect the tradeoff between the expected benefits and costs of R&D. Inventors will have incentives to invest such that the expected marginal returns to R&D equal the marginal costs of R&D.

The market for inventions provides additional guidance to inventors on the choice of R&D projects. Because market values of individual inventions differ, the returns to producing inventions through R&D depend on how the resulting inventions will be valued in the market. The expected returns to different directions in R&D will depend on scientific and technical opportunities and the potential market value of successful outcomes. Efficient levels of investment in R&D will be targeted to particular areas on the basis of expected returns to different types of inventions.

The market for inventions also provides guidance on how much to invest in commercialization and how to commercialize particular inventions. Commercialization of

inventions requires investment in communication, marketing, and sales efforts. Patent owners also need to identify potential adopters who might license or purchase their inventions. Patent owners need to choose among different methods of commercialization including transfers, licensing, cross-licensing, services, and contract R&D. In addition, patent owners must monitor potential infringement and if necessary invest in the legal costs of obtaining damages and injunctions. The market for inventions contains many types of transactions including embodied inventions. This implies that limited licensing does not indicate market failure, contrary to some studies (PatVal-EU Project, 2005, 2006, Giuri et al., 2007).

Patents play a significant and expanding role in the market for inventions as shown by substantial patents sales. For example, in 2011 Nortel Networks sold about 6000 patents and patent applications for $4.5 billion to a consortium of companies that included Apple, EMC, Ericsson, Microsoft, RIM, and Sony.[37] Serrano (2010) finds that the highest rates of transfers occur in information and communications technology (ICT) and the pharmaceutical and medical industries.

Patents are important for commercializing inventions through licensing. Using data from the Securities Data Corporation (SDC), Anand and Khanna (2000) find significant licensing activity in the Chemicals, Computers, and Electronics industries. Arora et al. (2007) apply extensive survey data on research labs in the U.S. manufacturing sector and show that patent protection of IP supports the market for technology licensing and the provision of specialized technology services. The market for inventions includes not only domestic markets but also

[37] Charles Arthur, "Nortel Patents Sold for $4.5bn," *The Guardian*, July 1, 2011, http://www.theguardian.com/technology/2011/jul/01/nortel-patents-sold-apple-sony-microsoft, Accessed January 25, 2014.

international transactions related to IP; royalty and licensing fees in international transactions grew faster than global GDP reaching $2.8 billion in 1970, to $27 billion in 1990, to $180 billion in 2009.[38]

B. Innovation

Because patents allow their owners to exclude others from making, using, or selling the inventions, they provide innovative control to IP owners. Patents are forward-looking because they offer IP protections for innovations based on patented inventions. Given these protections, firms have market incentives to develop innovations that use the invention in their products, production processes, and transaction techniques. The market for innovative control provides incentives for efficient levels of investment in innovation and for targeting investment toward innovations with desirable features.

The market for innovative control also promotes efficiencies in the organization of firms and industries. Weaker IP protections increases transaction costs for inventors and innovators. Inventors and innovators will have incentives to replace patent protections with other mechanisms including contracts and vertical integration.[39] With stronger IP protections, inventors and innovators can make decisions about transactions, outsourcing and vertical integration based on other business considerations. The market for innovative control also allows the entry of specialized intermediaries who can invest in commercialization, innovation and complementary assets.[40]

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[38] This is according to the World Intellectual Property Organization (WIPO) (2011, p. 9).

[39] See Arora (1996) and Arora and Merges (2004).

[40] See Yanagisawa and Guellec (2009) and Hagiu and Yoffie (2013).

As with securities markets, the market for inventions allows separation of ownership and control. The patent owner can obtain returns from the patented invention while delegating control over usage to licensees who employ the technology. The patent owner does not need to undertake all the transactions needed to apply the invention, but instead can rely on others to apply the invention. Delegation of control to licensees also provides benefits from specialization and division of labor. The patent owner can obtain returns from licensing and the licensees can apply their expertise to commercializing and applying the invention.

C. Investment in Complementary Assets

The market for innovative control also provides incentives to invest efficiently in *complementary assets*. Assets that are complementary to inventions include human resources, absorption of inventions, IP, product design, capital equipment, marketing, sales, procurement, and establishment of new firms. Patent protections allow companies to make investments in those complementary assets that are specific to particular inventions rather than in generic complementary assets. Invention-specific investment can generate greater economic returns. For a discussion of the importance of complementary assets in innovation, see particularly Teece (1986, 2006).

Inventors at Amazon Technologies obtained patent number 8615473 B2 for a “Method and system for anticipatory package shipping:”

> “According to one embodiment, a method may include packaging one or more items as a package for eventual shipment to a delivery address, selecting a destination geographical area to which to ship the package, shipping the package to the destination geographical

area without completely specifying the delivery address at time of shipment, and while the package is in transit, completely specifying the delivery address for the package." The basic invention is the discovery that the delivery address can be specified after shipping has begun. The value of this invention to a major e-commerce company such as Amazon.com is evident because shipping is a major aspect of their service and constitutes a significant part of their costs.

The Amazon patent specifies not only the basic invention but also looks ahead to innovations that will be introduced to the market based on that invention. Among the 24 claims, the patent contemplates different embodiments of the invention, including multiple computer systems that will communicate with each other, with one computer system initiating the shipment and the second computer system determining the destination and communicating with this first computer system.

Implementing a complex shipment system as envisioned in Amazon's patent will require investment in complementary assets, including computer software and hardware and machinery in the company's warehouses. To get some idea of the extent of this investment, consider that Amazon has spent over $5 billion on its facilities in five years, operates 40 fulfillment centers, and has plans to build more. Amazon's fulfillment center in Phoenix, Arizona covers an area greater than 28 football fields.[41]

[41] Megan Rose Dickey, 2012, "Mind-Blowing Facts About Amazon's Giant Shipping Operations," *Business Insider*, November 26, http://www.businessinsider.com/amazon-fulfillment-center-tour-2012-11?op=1 Accessed, April 14, 2014.

Amazon's shipping patent provides an indication of market incentives for investment in invention, innovation and complementary assets. In this example, Amazon is applying its own invention. Amazon's incentives to develop better shipping techniques are based on the market returns to improved shipping services and the lower costs of more efficient shipping technologies. Amazon has incentives to offer products and services based on its basic invention because of the market returns to developing and implementing its invention. Amazon has incentives to invest in complementary assets such as computers, fulfillment centers and specialized equipment to realize the full returns to its invention and related innovations. Amazon's patent allows it to exclude others from making, using, or selling its business method invention.

As illustrated by the Amazon's shipping method patent, patent protections protect incentives for invention, commercialization, innovation, and investment in complementary assets. The market for innovative control provides guidance for what types of inventions to pursue and the direction of subsequent development, innovation and complementary investments.

III. Financing Invention and Innovation

A key function of patents is helping to obtain *financing* of invention and innovation. Inventors attempt to create inventions by applying effort, knowledge, creativity, capabilities, insights, and scientific observations. If R&D is successful, the discovery may be valuable in commercial applications or as an input to further R&D. The discovery is the knowledge of the inventor, whether explicit or tacit, so it can be difficult to separate the discovery from the inventor. Patents help inventors to achieve financial separation from their inventions, which is

necessary for financing. By protecting IP rights, patented inventions serve as intangible real assets for entrepreneurial entrants and established companies.

A. Patents and Financial Separation

Financial separation of the invention from the inventor is critical for investment and financing of invention and innovation. The patented invention is an intangible real asset that embodies the inventor's discovery as well as subsequent development of the invention. The separation of the invention from the inventor is analogous to the creation of a firm by an entrepreneur. Myers (1999, p. 134) observes "[t]he company starts up with human capital. As and if it succeeds, an intangible real asset is created: the technology is embodied in product design; the production process used, and in the product's reputation with customers." Myers (1999, p. 134) points out "[t]his real asset separates from the people who created it and can in due course be appropriated by financial investors. The venture could not raise outside money otherwise."[42]

By separating invention from inventors, patents facilitate the financing of R&D. Patents support financing of R&D by independent inventors and specialized firms. As intangible real assets, patented inventions support invention and innovation by corporations. Graham et. al (2014) find that startups patent to obtain financing as well as seeking competitive advantage and deterring infringement. Arqué-Castells (2012) shows that investment by venture capitalists (VCs) funds the development of inventions and increases patenting by start-ups. Studies using aggregate industry data tend to show that VC funding tends to increase patenting (Arqué-Castells, 2012).

[42] See also Myers (2000).

Innovation requires costly investments in developing and commercializing inventions. The inventor must invest in communicating the discovery to others by codifying it in the form of technical reports, diagrams, blueprints, computer code, statistical analyses, and mathematical formulas. The inventor incurs costs of developing the invention in the form of models, prototypes, equipment, materials, chemical compounds, and biological matter. The inventor can embody the invention by investing in the development of new products, new manufacturing technologies or new transaction methods.

Inventors may not be able to invest efficiently in developing or commercializing their inventions if they cannot obtain financing. Innovation can be inefficient if financially-constrained inventors cannot transfer their inventions to others. When inventors face financial constraints and limits on market transferability of their inventions, the conditions of the Fisher Separation Theorem (1906, 1907, 1930) do not hold. This has important implications for invention and innovation.

Consider an inventor who has created an invention. The invention can be developed and commercialized through additional investment in innovation. In a two-period setting, for example, the optimal investment in innovation equates the expected marginal return to investment to the per-unit cost of investment.

To examine the implications of transferability for the inventor's decisions, suppose that the inventor is financially constrained and does not have sufficient funds to cover the costs of investing efficiently in innovation. Also, suppose that the inventor cannot obtain financing to develop and commercialize the invention. The innovator will be forced to under invest in innovation and if a minimum level of investment is needed, the innovation may be unable to develop the innovation at all. This problem is readily solved if the inventor can transfer the

invention to others. Buyers that are not subject to liquidity or financing constraints will be willing to pay up to the maximum value of the innovative project. Buyers will develop the innovation efficiently either through investment of their own funds or by obtaining financing for the costs of innovation.

Consider an independent inventor who cannot transfer the invention and also is subject to liquidity and financing constraints. The inventor must invest in innovation and will face a tradeoff between consumption and investment in innovation. An inventor who cannot transfer the invention to others and is financially and liquidity constrained faces interconnected consumption and investment decisions. The inventor's investment in innovation will reflect his marginal utility of consumption, subjected discount rate and initial endowment.

Suppose instead that the inventor can transfer the invention to others who then can efficiently invest in developing the innovation. Then, because others can invest efficiently, the investment project will attain the maximum expected value. The inventor will maximize the benefits of consumption subject to a budget constraint that includes the returns from the sale of the invention. The efficient investment level will not depend on the costs and benefits of innovative investment and not on the inventor's endowment or preferences.

This discussion demonstrates how patents generate gains from trade by facilitating the financial separation of inventions from their inventors. The inventor will be made strictly better off by transferring the invention to others than by developing the innovation himself. This follows from the standard Fisher Separation Theorem. Inventors who are financially and liquidity constrained benefit from transferring inventions to others in the market who can invest efficiently in innovation. Innovators who acquire inventions benefit by investing in developing and commercializing inventions.

B. Patents and the Financing of Innovation

Patents also can provide a means of financing invention and innovation. Independent inventors and specialized firms can obtain financing for the invention by offering to license or transfer the patent to a company that provides financing. Companies that fund research can obtain an option to license or purchase the inventions after they are patented. If the inventor or specialized firm has already obtained a patent, the patent can serve as collateral for financing to develop the invention and to innovate based on the invention. Nathan Myrvold recommends the creation of patent-backed securities and suggests that "the business of invention would function better if it were separated from manufacturing and developed on its own by a strong capital market that funded and monetized inventions."

Patents are intangible real assets that contribute to the market value of the firm. The patent provides IP protections for an investment project *V*. Suppose that the firm's assets consist of a patent with expected market value *EV*. Corporations obtain financing based on their patents. In the balance sheet of a firm financed by debt and equity, the market value of debt and equity equals the expected market value of the firm's intangible real asset, *EV*.

Patents can represent "assets in place" in the sense of Myers (1977). Patents that are "assets in place" contribute to the market value of the corporation. Patented inventions affect the firm's earnings through licensing revenues or as productive inputs. Studies show that patent ownership by corporations contributes significantly to their market value.[43] The market value of patent ownership reflects the value of own-use of technology, the benefits of cross-licensing, and earnings from licensing. Companies earn significant revenues from licensing patents. For

[43] On the financial valuation of patents see Munari and Oriani (2011) and Murphy et al. (2012). See Hall (1993) and Hall et al. (2007) on the stock market value of R&D investment.

example, IBM earns about $1 billion annually from licensing revenues.[44] Robbins (2009) estimates that in 2002 US corporations reported about $67 billion in earnings from IP protected by patents and trade secrets. Adams et al. (2013) study the effect of patent ownership on the value of companies based on licensing revenues of specialized patent intermediaries.

Patents also can represent "growth opportunities" in the sense of Myers (1977). Patented inventions serve as "growth opportunities" because the company can develop the invention, innovate based on the invention, and invest in complementary assets. Also, the company can develop new technologies that extend their patented inventions. Myers (1977) points out that assets that are "growth opportunities" can function as call options because they involve investment decisions under uncertainty.

The capital structure of the firm can have incentives effects on investment in invention and innovation. Myers (1977) shows that equity financing is best for inducing firms to maximize expected value of projects. This is because debt financing could cause the firm to avoid some projects that have positive expected value. Equity financing provides incentives for efficiency in the choice of R&D projects as well.

Debt financing is useful as an incentive mechanism for inducing effort. Jensen and Meckling (1976) argue that with moral hazard, debt financing gives managers incentives for more efficient performance in comparison to equity financing. Poblete and Spulber (2012) show generally that the optimal contract with moral hazard and limited liability takes the form of debt. This is because debt-style contracts serve to concentrate payments to the agent in the best states, which induces efficient levels of effort. Poblete and Spulber (2014) extend this analysis to R&D and show that debt-style contracts are the optimal contract for inducing R&D effort.

[44] Barinka (2014).

Investment in R&D by companies provides evidence that the exclusivity provided by patents protects investment-backed expectations. Corrado et al. (2009) consider average annual capital spending during 2000-2003 and estimate that companies invested approximately $640 billion in R&D and development of computer software.

The role of patents as intangible real assets further shows that patents are not "rewards" for inventors. Inventors are no more rewarded by patents than companies are rewarded by registering securities. Indeed, patents as intangible real assets are analogous to *financial assets* in many ways. Just the market for inventions provides returns and control to patent owners and determines the value of patented inventions, so securities markets provide returns and control to owners of securities and determine the value of publicly-traded firms. Inventors seeking patents must make filings and disclosures to the USPTO including a description of the invention and information showing that the invention is useful, novel, and non-obvious. Firms selling securities must register those securities with the Securities and Exchange Commission (SEC) and make various disclosures including a description of the security, an explanation of the company's properties and business, information about the company's management, and certified financial statements.[45] Just as each patent is different, so each corporate security is different, Procter & Gamble stock is not the same as ExxonMobil stock.

IV. Public Policy towards IP

The present analysis of the market for inventions has implications for public policy towards IP. The design of IP policy should consider the patent system overall, which includes the market for inventions and other private institutions such as industry consortia and SSOs. The

[45] See http://www.sec.gov/about/laws.shtml, accessed April 3, 2014.

patent system also includes public institutions, which in the U.S. involves all three branches of government. The Congress establishes the rules of the system through legislation such as the 2011 America Invents Act (AIA). The Executive branch reviews patent applications and grants patents through the USPTO, which is an agency of the Department of Commerce. Finally, the Judiciary adjudicates legal cases involving patent grants and patent infringement. Patent law encompasses a rich set of legal precedents including many Supreme Court decisions.

A. The Market Foundation View versus the "Rewards" View of Patents

The market foundation role of patents refutes the notion that patents are government-provided "rewards" for inventors. The "rewards" view is a mischaracterization of the purpose and institutions of the patent system. The market foundation role of patents and the "rewards" view suggest substantially different public policies towards IP.

At first glance, it is easy to see why many believe that patents are "rewards" for inventors. The USPTO states "A patent is an intellectual property right granted by the Government of the United States of America."[46] Because some patented inventions are quite valuable in the market place, one might well be tempted to conclude that the U.S. government has given a valuable property right to the patentee. Yet the meaning of the word "grant" in this context is not an award, gift, donation, or subsidy. Rather the word "grant" indicates that the government recognizes the inventor's right to exclude others from making, using or selling the invention.

The government does not transfer a valuable asset to inventors but instead recognizes the ownership of the asset by the inventor. The inventor's efforts, not the government patent grant,

[46] http://www.uspto.gov/patents/

generate the invention. The patent grant is based on the features of the invention, the details of the application, and is contingent on whether the invention is useful, novel, and non-obvious. The patent certifies that the inventor meets criteria such as the first-to-invent, or now, the first-to-file.

The "rewards" view of patents is inconsistent with the institutions of the patent system. The returns received by the patent owner are provided by market participants not by the government. The patent grant does not involve any asset or monetary transfers from the government to the patentee. The patent grant does not specify the market value of the patented invention, which is determined by the features of the invention and by demand and supply in the market for inventions. In addition, the patent owner's returns are generated by investment in developing, commercializing and applying the invention. Many of these investments are made after the patent is granted.

The "rewards" view suggests that anticipation of obtaining patents provides incentives for invention. Inventors would not devote effort and make investments in R&D unless they expect to obtain economic returns. However, patent owners only receive the market value of the patented invention net of the costs of invention and commercialization. Inventors bear the risks associated with invention and commercialization. The inventor's R&D project may not succeed and the invention may not meet the criteria for patentability. The patenting process itself is costly and many applicants do not receive patents. Even if the inventor receives a patent, most patents have little if any market value. The patent grant does not provide incentives; rather it provides the basis from further developing the invention, commercializing the technology, introducing innovations to the market.

The patent grant is not designed to provide a reward for any particular type of invention, as if it were a "prize" for winning a contest, a government subsidy, or an employer bonus.[47] The patent grant is not a financial reward designed to induce some type of inventive behavior or level of effort. Also, the grant of a patent by the USPTO is not based on the costs of R&D or the efforts of the inventor in making the discovery (Spulber, 2011). The patent grant does not reward the inventor for disclosing the invention. As already noted, disclosure provides benefits to both patentees and potential adopters by reducing transaction costs in the market for inventions. Disclosure identifies the features of the invention and helps to guard against infringement.

B. The Scope of Patents

An important implication of the market foundation role of patents is that patent claims should be viewed prospectively. This confirms and extends Kitch's (1977) argument that patents should have sufficient scope to encourage further invention and innovation and to foster coordination. Patents not only recognize creative work, they provide IP protections for future creative work. The patent's claims extend beyond the completed work because inventors and patent owners plan to develop the invention and to invest in innovation.

The market for inventions is a market for innovative control. This means that patents do most of their work after they have been granted. Prices and terms of transactions in the market for inventions provide guidance on how to develop the invention, what innovations will apply the invention, what types of complementary assets should be obtained, and financial investments

[47] See Roin (2014) for an overview and discussion of the literature that discusses "prizes" for inventors.

in invention and innovation. Patents thus help provide guidance to inventors, innovators and investors.

This policy recommendation contrasts with the "rewards" view of patents, which suggests that patent scope should be narrow to limit the returns to inventors receiving the patent and to open the way for other patents to give additional rewards to future inventors. For example, Merges and Nelson (1990) argue that the scope of patents should be constrained because "In many industries the efficiency gains from the pioneer's ability to coordinate are likely to be outweighed by the loss of competition for improvements to the basic invention." Merges and Nelson (1990, p. 870) are concerned that broad patent scope will discourage "subsequent inventions that not only substitute for the initial invention, but also improve on it in some way."[48]

The market foundation role of patents supports broader patent scope because patents are forward looking. Patents increase transaction efficiencies in the market for invention, provide innovative control, and facilitate financing of invention and innovation. These functions encourage competition: property rights increase entry into the market for inventions. Greater financing of invention and innovation increases entrepreneurial entry and competition in the market. Patents can cover development, commercialization, and innovation without ruling out improvements offered by others. Also, the patent examination process and the courts limit the scope of patent claims. Patent owners have incentives to limit the scope of their claims to

[48] See also Merges and Nelson (1994, p. 22) "Inventors are coming up with inventions that the broad prospect holder is challenging in court. The danger is that competitors will be harassed out of the field. There is every reason to believe that this would diminish not only the energy devoted to developing the prospect but also cut down on the diversity and creativity of the development.")

increase the likelihood that the USPTO will grant the patent. Patent owners also have incentives to limit the scope of claims to reduce the risk that patents will be challenged and found invalid in the courts.

C. Incremental Inventions, "Patent Hold-Up", and "Patent Thickets"

Another common critique of patents based largely on the "rewards" view is that IP rights block incremental inventions, see particularly Merges and Nelson (1990). This concern is applied to both individual patents and to sets of complementary patents, referred to as patent hold-ups, patent thickets, patent logjams, or the anti-commons. Little if any evidence is advanced for these policy concerns.

However, the history of patents demonstrates that the patent system has accommodated a continual stream of both major inventions and incremental inventions. As Mossoff (p. 205) observes: "From the sewing machine to automobiles to airplanes to radios, incremental innovation is omnipresent in the historical evolution of science and technology." Selgin and Turner (2011) explain how James Watt's steam engine patent did not prevent subsequent innovations but "may actually have hastened the development of the high-pressure steam engine by inspiring Richard Trevithick to revive a supposedly obsolete technology so as to invent around them."[49]

The many contributions of patents to the development of inventions and the introduction of innovations are well documented. Howells and Katznelson (2013) find that "court decisions upholding Edison's patent generated a surge of patent filings in the incandescent lamp classes." In the early aircraft industry, Howells and Katznelson (2014a) find "plentiful evidence of robust

[49] Selgin and Turner (2011, p. 841).

US aircraft developments in 1912–1916, the period of the alleged patent hold-up." In the early radio industry, Howells and Katznelson (2014b) demonstrate that the diode patent was followed by extensive and vigorous development of the later triode technology.

A related criticism of patents based on the "rewards" view, is that IP rights are unnecessary because incremental inventions would occur anyway. According to this view, rewards from patent ownership must be "excessive" because inventors have sufficient incentives to develop inventions with weaker IP rights. For example, Shapiro (1980) suggests that when public knowledge advances rapidly, incremental improvements are "in the air." Shapiro further argues that independent invention is more likely for inventions that are "easily achieved." The market foundation role of patents provides transaction efficiencies for inventions, innovative control, and financing. These economic benefits are present regardless of whether the initial invention was "in the air" or "easily achieved." In practice, it is difficult if not impossible to distinguish between inventions that are easy or hard to obtain. Inventions often involve a complex mixture of inspiration and hard work. It is also not feasible to distinguish between inventions that are breakthroughs or "in the air" for the purpose of regulating royalties. Criticisms of the patent system based on the "rewards" view suggest that patents are granted for inventions that fail the tests of being useful, novel, and non-obvious.[50] These issues have to do with the functioning of the patent examination process and can be addressed through improvements in management and organizational design. However, such administrative issues differ from the question of whether patents support exchange in the market for inventions.

[50] See for example Shapiro (2008). Shapiro (2008) recommends applying the "independent inventor defense" in infringement cases, which would eliminate or substantially weaken the exclusion function of patents.

Some complaints about the patent examination process are the product of hindsight. Many inventions that were once useful, novel and non-obvious no longer are as technological change reveals alternatives and makes past inventions not only obsolete but quaint by comparison. Rapid technological change can speed up change in subjective perceptions of past inventions.

Another common criticism of patents based on the "rewards" view is that patents restrict innovation by discouraging the use of patented inventions. According to this argument, patent owners can "hold-up" infringers by threatening injunctions and damage remedies for infringement.[51] Infringers are said to be unaware of the patents and surprised by legal claims. The hold-up argument further assumes that infringers are locked in to the technology because of high costs of designing around the patented technology and the costs of switching to a new technology. The "hold-up" argument concludes that patent owners will take advantage of these costs by to increase royalty demands in license negotiations.

The theoretical "hold-up" argument tends to ignore incentives for coordination through markets for inventions (Spulber 2013c). Patent owners and producers have incentives to contract before any infringement occurs and before producers make complementary investments. Evidence for this comes from extensive investment and industry growth that occurs after licensing and cross-licensing of inventions.

Even after infringement is discovered, patent owners and producers have incentives to negotiate licensing agreements. Patent owners do not have incentives to seek excessive royalties because they benefit from producers marketing and sales efforts that increase usage of the patented invention. Patent owners also benefit from producers' making investments in new

[51] See for example Farrell et al. (2007).

products, production processes and transaction techniques that apply the inventions. Patent owners would not wish to discourage investments in innovation and complementary assets. Also, in practice, producers can develop alternative technologies, licensing substitute technologies, or pursuing alternative activities that do not require the infringed technology. These activities are affected by royalties; excessive royalties would discourage use of the patented invention and encourage the search for alternatives. Market forces including competition from past, present, and future inventions constrain royalties.

D. Public Goods and the Market for Inventions

Critics of the patent system often point out that inventions are "public goods." Consumption of inventions is "non-rivalrous" in the sense that multiple firms can apply the same invention. Unlike eating a cake, which must be divided among consumers, many firms can use the same invention without depleting the original resource. For example, Stiglitz (2008, p. 1700) states "I want to emphasize that efficiency *in use* means knowledge should be freely available. The problem is that intellectual property rights circumscribe the use of knowledge and thus, almost necessarily, cause inefficiency."[52] Again applying the "rewards" view, Stiglitz (2008, p. 1706) observes "The patent system can only be justified, given all its costs, in terms of dynamic efficiency: the benefits that result from an enhanced pace of innovation."

The non-rivalrous or public good nature of inventions by no means implies that technology cannot be allocated efficiently by a system of property rights. Access to patented technology can readily be sold and distributed to multiple users through licensing, cross-licensing, subscriptions, and other types of contracts. There are many types of markets for goods and services that are

[52] Emphasis in original.

non-rivalrous but excludable. Markets have long existed for printed matter such as books, newspapers, magazines, and journals, and other types of analog and digital media. Markets also allocate access to shows and movie presentations. All types of video and audio programming are sold and distributed through cable television or streaming over the Internet. Access to other types of content, including news, technical information, education, e-books, games, movies, music, and applications programs (apsp), is sold and distributed over the Internet.

The non-rivalrous or public good nature of inventions also does not imply that such goods should be freely available. There are marketing, distribution, sales and other types of transaction costs for information goods such as inventions. There are also costs of communication and codification of technological information particularly when the inventor has tacit knowledge that is difficult to transmit to potential adopters.

Even if distribution and transaction costs were zero, inventions should not be free available because patent owners incur costs of developing the invention, creating innovations, and investment in complementary assets. The best way to recover these costs is through a price system. Simply labeling technology as a public good does not imply that inventors should rely on government subsidies obtained from general taxation. Also, labeling technology as a public good does not imply that firms employing the technology should receive it at no cost. Efficiency is achieved by the "user pays principle." Firms have incentives to make efficient technology adoption decisions and efficient R&D investments when they pay technology. If there are efficiencies from lower per-unit royalties, access to technology can be sold using a combination of lump-sum and per-unit royalties.

Some critics of the patent system apply inappropriate benchmarks to the market for inventions. These benchmarks are based on the theoretical market model in neoclassical economics, which assumes "rivalrous" consumption. According to Troy and Werle (2008) for example,

> "[f]undamental and strategic uncertainty related to patent trading – a specific decontextualized institutional form of knowledge property – has prevented functioning markets for patents from emerging. Apparently, patent transactions are not made in perfect, anonymous neoclassical markets. Also, if we define markets less rigidly as institutional fields constituted by sellers and buyers, intermediaries and regulators, sharing rules, standards, and norms which govern transactions, we can hardly speak of a market for patents."

This argument is based on the unrealistic definition of markets as centralized auctions, such as organized financial exchanges. The authors also rule out transactions involving intermediaries, regulators, standards and norms. This definition not only eliminates financial exchanges but also practically any market, because practically any market has a microstructure with these features (Spulber, 1999). Criteria that define almost all markets out of existence should certainly not be applied to patents and are misleading for public policy.

Markets rarely conform to the neoclassical economics paradigm of homogenous goods, anonymous trading through an exogenous auctioneer, price-taking behavior, or rivalrous consumption. This combination of features is absent from practically all markets, and certainly should not be normative standards applied to markets for inventions. Many markets involve highly differentiated products, for example all properties in commercial and residential real estate differ in terms of combinations of location and building features. Even securities markets have submarkets for the stocks of individual companies, for example the New York Stock Exchange has specialists that make the market for the stock of individual firms. Many markets involve an absence of anonymity such as labor markets or markets for outsourcing contracts. Many markets involve price-setting by sellers or price negotiation between buyers and sellers.

V. Antitrust Policy towards Patents

The present analysis of the market for inventions has implications for antitrust policy. Protection of IP and antitrust policy are complements because protecting IP promotes competition in the market for inventions and in markets for goods and services that embody or are manufactured with patented inventions. Conversely, antitrust policy that favors competition in market for invention and in product markets will increase incentives to innovate. This implies that both patent policy and antitrust policy should favor stronger IP rights. Patent policy and antitrust policy should avoid making exceptions to protections of IP rights. Policy makers thus should avoid restrictions of IP rights for arbitrarily-selected cutting-edge technologies such as software, business methods, or biotechnology.

A. Patents and Competition

The many varieties of competition in the market for inventions and related markets refute the common misconception that patents give their owners an economic monopoly. For example, Kenneth Arrow's (1962) classic analysis states "[w]ith suitable legal measures, information may become an appropriable commodity. Then the monopoly power can indeed be exerted."[53] Boldrin and Levine (2013) argue that patents provide "a monopoly as a reward for innovation" and that there is "little doubt that granting a monopoly for any reason has the equally ill consequences we associate with monopoly power." The patent as monopoly argument has been refuted by John Stuart Mill (1848), Kitch (1977, 2000) and Spulber (2013).[54]

[53] See also Nordhaus (1969, 1972), Scherer (1972), and Gilbert and Shapiro (1990).

[54] John Stuart Mill (1848, p. 932) observes that "the condemnation of monopolies ought not to extend to patents." This is quoted in Machlup and Penrose (1950, p. 7).

Advocates of the "rewards" view of patents typically conclude that patents are "excessive" because rewards exceed the inventor's contribution to social welfare. For example, Stiglitz (2008, p. 1706) states "The fundamental problem is that under the patent system the rewards do not correspond to the marginal social returns." Similarly, Shapiro (2008, p. 112) maintains that "The core problem with the current U.S. patent system explored here is that … the patent system predictably provides excessive rewards to patent holders. The term 'excessive rewards' is defined here to mean rewards that exceed the patentee's actual contribution to economic welfare."

There is no empirical evidence for the assertion that patent owners systematically earn "excessive" rewards. In any case, there is no intrinsic value of an invention that departs from its market value. Economic analysis has long identified the value of goods and services as being given by market prices. Competition in the market for inventions strongly suggests that patent owners earn market rewards. A patent does not confer an economic monopoly because access to the market for inventions, markets for products or financial markets remains unimpeded.

The inventor's incentives depend on anticipation of the market value of the invention. But, patents serve to promote competition among inventors and among adopters. By reducing transaction costs in the market for inventions, patents reduce the costs of entry and operation in that market. Competition in the market for inventions *limits* inventors' rewards. A patent faces competition from past, present, and future inventions. For example, the USPTO issued 276,788 patents in 2012. Patents filed on or after June 8, 1995 have a term of twenty years from the time of filing, so the stock exceeds two million patents. See Table 1 for the number of patents issued in the US from 1963 to 2012.

A patented invention also faces *potential* competition from future inventions. Thus, a patent does not create a barrier to entry into the market for inventions because any other patented invention can enter the market for inventions. Any invention that is novel and thus does not infringe on patented inventions can enter the market for inventions.

A patented invention faces additional competition from inventions that are not protected by IP rights including inventions that were patented but whose term has expired. For example, patented pharmaceuticals face competition from generics. A patented invention faces competition both within and across the patent categories established by the USPTO. This is because the patent categories have to do with the properties of the inventions, which need not correspond to adopters' uses for inventions. For example, a computer software invention such as an e-mail program can compete with a computer hardware invention, such as a fax machine.

The patent system, by creating transferable assets from inventions, translates market competition into incentives for invention, commercialization, and innovation. When there is a market for inventions, competition among inventors increases incentives for invention and innovation (Spulber 2013a, 2013b). Additionally, when there is a market for inventions, competition among adopters increases incentives for invention and innovation. Without such protections, companies resort to secrecy and vertical integration, which can cause competitive pressures to reducing incentives to invent and to innovate.

B. Antitrust Policy and the Market for Inventions

Antitrust policy towards patents should consider their role as the foundation of the market for inventions. This immediately eliminates the false conflict between patents as monopoly

rewards for inventors and antitrust as rent control. The antitrust policy objectives of promoting competition and consumer welfare complement the market foundation role of patents.

Nor does a patent create barriers to entry in product markets. Any product that uses other patented inventions or that uses any technology that does not infringe on the patented invention can enter the product market. Thus, producers that offer product that applies a patented invention face competition in the product market. Competition in the product market from firms using other technologies limits the economic returns to a particular invention.

A patented invention faces competition both from inventions that are substitutes and from inventions that are complements. The economics definition of substitute (complementary) products refers to those products whose demand increases (decreases) with an increase in the price of the other products. Products are economic substitutes if some buyers must be willing to switch some of their consumption from one good to another in response to changes in the relative prices. The concept of economic substitutes only requires products to be comparable rather than identical, which is referred to as perfect substitutes. Products are economic complements if some buyers derive benefits from joint consumption. Buyers can derive benefits from consuming a selection of complementary products, so that joint consumption of all complementary products is not necessary, in contrast to perfect complements.

Competition and entry of substitutes in the market for invention limits or eliminates the market power of inventions. When inventions are vertically differentiated, that is buyers can rank inventions consistently on the basis of quality, buyers' willingness to pay for a particular invention is limited by the incremental contribution of that invention to their profits. Inventions other than the best invention are not adopted and inventors need not recover their costs of invention. Buyers will tend to apply the best invention and royalties are less than or equal to the

incremental benefits of the best invention as compared to the best alternative. This outcome corresponds to dominant designs or to technology standards based on the best technology. The best technology is subject to change as new inventions continue to enter the market.

When inventions are horizontally differentiated, multiple technologies may be adopted in the market for inventions. Chamberlin's (1933) model of monopolistic competition is useful for characterizing competition in a particular segment of the market for inventions. This model features price setting by suppliers and competitive entry. Although suppliers have pricing power, entry dissipates rents. With up-front fixed-fee royalties, the equilibrium royalty will equal the cost of invention divided by the number of licenses offered by every inventor plus licensing costs. A similar argument can be made when inventors charge a royalty based on the units of output sold by adopters.[55] Even if inventors have pricing power, entry of substitute inventions drives inventors' economic profits to zero.

[55] Consider Chamberlinian competition among inventors who enter the market to supply different inventions. Suppose that an inventor incurs fixed costs K to produce a new invention, to obtain a patent, and to commercialize the invention. Suppose that an inventor incurs a distribution cost c to license the invention to each licensee, which can be positive or equal to zero. Inventors offer an up-front fixed fee royalty of R to each licensee. Let $D(R)$ be the total number of adopters per invention at a symmetric equilibrium when all inventors offer the same royalty. Let $D'(R)$ be the slope of each inventor's demand when all inventors offer the same royalty. Given the royalties charged by other inventors, each inventor chooses a royalty that maximizes profit taking as given the royalties set by other inventors. For each inventor, the marginal revenue from licensing equals the cost of licensing to an adopter, c, $D(R; n) + RD'(R) = c$. Inventors conduct R&D and continue to enter the market until each inventor earns a zero

Even in the absence of substitutes, inventions compete for economic rents with complementary inventions. The entry of additional complementary inventions tends to diminish the returns to each invention when adopters of the inventions have a given total benefit. This is the case even when complementary inventions are necessary for adopters to produce final products. When complementary inventions are not necessary, competition among inventions constrains the returns to a particular invention based on its incremental contributions to the final products. The presence of substitutes for individual complementary inventions and substitutes for entire platforms provide competitive pressures that limit royalties.[56]

VI. Conclusion

The economic benefits of patents derive from their major contributions to the formation of the market for inventions. The U.S. patent system offers many important features that contribute to transaction efficiencies and increase competition. The patent system provides IP protections that support a market for innovative control. The patent system further supports private financing of invention and innovation. The market foundation role of the U.S. patent system has a proven record of performance, having fostered significant technological change and economic growth.

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profit. The royalty per license equals the average cost of invention and licensing, $R = k/D(R) + c$. Together, these conditions determine the royalty charged by each inventor and the number of inventors that enter the market for inventions.

[56] Layne-Farrar et al. (2007) consider competition from substitute inventions within categories of complementary technologies.

The market foundation role of patents presents a complex but realistic analysis of invention and innovation. The “rewards” view of patents does not take full account of either public or private institutions that form the patent system. Critics of the patent system often highlight the legal costs of the patent enforcement. The legal costs of the patent system should not be viewed as a reward to inventors, but instead can be better understood as a cost of deterring infringement. Such costs cannot be taken in isolation; they must be weighed against the benefits of generated by the market for inventions.

The analysis in this paper suggests that public policy towards IP should be based on long experience with markets for all types of goods, services, and financial assets. Economic understanding of how market mechanisms contribute to allocative and dynamic efficiency extends readily to invention and innovation. The market for inventions, whether in the form of disembodied technology or discoveries embodied in products, services or production processes, offers efficiencies that are closely related to how markets perform in other areas of the economy. Private ordering offers a variety of institutions such as licensing, cross-licensing, transfers, and contractual R&D for addressing the specific features of invention and innovation.

Antitrust policy towards IP should be based on the tradition of promoting competition and economic efficiency in other types of markets. The market foundation role of patents shows that stronger IP rights increase competition, innovation, and consumer welfare. Antitrust policy most effectively promotes innovation, competition, and transaction efficiency when it recognizes the market foundation role of patents.

U.S. Patent Statistics Chart
Calendar Years 1963 - 2012

Year of Application or Grant	Utility Patent Grants, All Origin Total	Design Patent Grants	Plant Patent Grants	Reissue Patent Grants	Total Patent Grants
2012	253,155	21,951	860	822	276,788
2011	224,505	21,356	823	1,029	247,713
2010	219,614	22,799	981	947	244,341
2009	167,349	23,116	1,009	453	191,927
2008	157,772	25,565	1,240	647	185,224
2007	157,282	24,062	1,047	508	182,899
2006	173,772	20,965	1,149	519	196,405
2005	143,806	12,951	716	245	157,718
2004	164,290	15,695	1,016	298	181,299
2003	169,023	16,574	994	421	187,012
2002	167,331	15,451	1,133	460	184,375
2001	166,035	16,871	584	480	183,970
2000	157,494	17,413	548	524	175,979
1999	153,485	14,732	420	448	169,085
1998	147,517	14,766	561	298	163,142
1997	111,984	11,414	394	277	124,069
1996	109,645	11,410	362	279	121,696
1995	101,419	11,712	387	316	113,834
1994	101,676	11,095	499	317	113,587
1993	98,342	10,630	442	332	109,746
1992	97,444	9,269	321	360	107,394
1991	96,511	9,569	353	263	106,696
1990	90,365	8,024	318	370	99,077

Year of Application or Grant	Utility Patent Grants, All Origin Total	Design Patent Grants	Plant Patent Grants	Reissue Patent Grants	Total Patent Grants
1989	95,537	6,092	587	317	102,533
1988	77,924	5,679	425	244	84,272
1987	82,952	5,959	229	245	89,385
1986	70,860	5,518	224	260	76,862
1985	71,661	5,066	242	276	77,245
1984	67,200	4,938	212	300	72,650
1983	56,860	4,563	197	362	61,982
1982	57,888	4,944	173	271	63,276
1981	65,771	4,745	183	365	71,064
1980	61,819	3,949	117	285	66,170
1979	48,854	3,119	131	309	52,413
1978	66,102	3,862	186	364	70,514
1977	65,269	3,929	173	410	69,781
1976	70,226	4,564	176	422	75,388
1975	72,000	4,282	150	378	76,810
1974	76,278	4,304	261	435	81,278
1973	74,143	4,033	132	314	78,622
1972	74,810	2,901	199	275	78,185
1971	78,317	3,156	71	246	81,790
1970	64,429	3,214	52	269	67,964
1969	67,559	3,335	103	233	71,230
1968	59,104	3,352	72	186	62,714
1967	65,652	3,165	85	196	69,098
1966	68,405	3,188	114	179	71,886
1965	62,857	3,424	120	246	66,647
1964	47,375	2,686	128	200	50,389

Year of Application or Grant	Utility Patent Grants, All Origin Total	Design Patent Grants	Plant Patent Grants	Reissue Patent Grants	Total Patent Grants
1963	45,679	2,965	129	198	48,971

Source of data: USPTO, http://www.uspto.gov/web/offices/ac/ido/oeip/taf/reports.htm Accessed January 18, 2014.

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