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Patents as Escalators

Amelia S. Rinehart*

“You have to risk a strikeout in order to hit a home run.”¹

ABSTRACT

High technology companies commit time, effort, and resources to innovation. Over the course of a research and development project, an innovative company may face several sequential decisions regarding whether to continue to invest in the project and whether to commercialize the discoveries that have been made. Companies often seek patents early in the research and development process to receive the right to exclude others from practicing the invention. Given a current trend toward earlier and earlier patent filing, several scholars suggest that this strategy could leave many inventions underdeveloped; companies may treat patents like real options, deciding later where to place their resources to maximize their utility. This Article introduces the escalation of commitments, which is a behavioral phenomenon observed in decision making under uncertainty to the current trends in patent filing. The Article further discusses the ramifications of innovative companies' escalating commitments to developing patented technology. Finally, the Article proposes that patents act to facilitate such commitment, in part because patents keep sunk costs relevant to the patent owner making decisions regarding further commitment. In this manner, patents may escalate the commercialization of patented technology.

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1. Curt Schleier, *Copycat? No, Joe Wilson Made His Own Xerox Mark*, INVESTOR'S BUS. DAILY, (Dec. 30, 2009) (quoting Xerox's President Joe Wilson), <http://www.investors.com/NewsAndAnalysis/Article/516631/200912301648/Copycat-No-Joe-Wilson-Made-His-Own-Xerox-Mark.aspx>.

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On November 22, 1940, the New York Times reported that an obscure patent attorney named Chester F. Carlson received US Patent No. 2,221,776 for a new photography method that would allow for the instantaneous creation of permanent printed copies.² After obtaining several more related patents and being rejected by countless companies for potential licensing deals, Carlson sold his patents to the Battelle Memorial Institute, an Ohio research organization with no manufacturing capability.³ Two years later, Battelle exclusively licensed the Carlson patents to Haloid Corporation of Rochester, New York,⁴ a photographic paper company fighting for its life against much larger local rival, Kodak.⁵ The new process became known as xerography, Haloid became Xerox, and the rest became history—but not until the pioneering patents on the underlying technology expired.⁶ Why did Carlson and Xerox pursue the commercial development of a patented invention despite long delays, product

2. *Electrical Photos Speed Development*, N.Y. TIMES, Nov. 22, 1940, at 22 (describing Carlson's technology).

3. DAVID OWEN, COPIES IN SECONDS 127-29 (2004).

4. Erwin A. Blackstone, *Restrictive Practices in the Marketing of Electrofax Copying Machines and Supplies: The SCM Corporation Case*, 23 J. INDUS. ECON. 189, 189 (1975).

5. OWEN, *supra* note 3, at 123-27.

6. Until 1999, patents received a seventeen-year term from the date of issue. See Bruce Lehman, *Major Biotechnology Issues for the U.S. Patent and Trademark Office*, 33 CAL. W. L. REV. 49, 55-56 (1996). Hence, Carlson's earliest patent expired in November 1957. See US Patent No. 2,221,776 (filed Sept. 8, 1938) (issued Nov. 19, 1940). The first successful commercial copier utilizing xerography, the Xerox 914 model, made its first sale in 1961. OWEN, *supra* note 3, at 237. Currently, patents receive a twenty-year term from the date of filing or a priority date determined by statute. See 35 U.S.C. § 154(a) (2006).

failures, discouraging disinterest from potential licensees indicating no demand for the end product, and patents nearing their expiration dates? This Article aims to answer that question by introducing the concept of escalation of commitment, a behavioral phenomenon observed in decision making under uncertainty, to technological research and development decisions.

High-risk, high-reward innovation, like xerography and many other inventions, entails not just the likelihood of high costs of research and development, but the likelihood of great uncertainty with regard to both technical and commercial success. Viewing the research and development process as well as the patent grant through a “real option” lens, where obtaining the patent may be described as purchasing an option to litigate and commercialize the invention it claims, scholars have suggested that current patent policy encourages earlier and earlier patenting of inventions, which, in turn, encourages firms to under develop their many patented prospects.⁷ Underdeveloped but patented technology, these scholars argue, should be considered a drain on the patent system and a cost to society at large.⁸

Learning from behavioral research and patent policy, this Article presents the novel argument that patents may incentivize commercialization of high-risk, high-reward innovations by encouraging investment commitments to high-risk technology. Accordingly, rather than posing a danger of underdevelopment, patents may encourage the commercialization of patented inventions, especially those with large sunk costs and highly uncertain technical achievement or commercial success. Despite discouraging feedback, Carlson and Xerox persisted and achieved extraordinary success over time. Other famous inventors, including Thomas Edison, the “father of invention,”⁹ and Edwin Land, who revolutionized instant photography,¹⁰ often abandoned patented projects only after

7. See, e.g., Michael Abramowicz, *The Danger of Underdeveloped Patents*, 92 CORNELL L. REV. 1065 (2007) (presenting the case for underdevelopment relying on real options logic); Christopher A. Cotropia, *Describing Patents as Real Options*, 34 IOWA J. CORP. L. 1127, 1132 (2009) [hereinafter Cotropia, *Real Options*]; Christopher A. Cotropia, *The Folly of Early Filing in Patent Law*, 61 HASTINGS L.J. 65 (2009) [hereinafter Cotropia, *Folly*]; Videotape: Patents as Options (Shaun Martin and Frank Partnoy, Washington Univ. in St. Louis 2005) (on file with author).

8. See Cotropia, *Folly*, *supra* note 7, at 112-13.

9. See DVD: *Biography—Thomas A. Edison: Father of Invention* (A&E Home Video 2006).

10. Eric Pace, *Edwin H. Land is Dead at 81; Inventor of Polaroid Camera*, N.Y. TIMES, Mar. 2, 1991, <http://www.nytimes.com/1991/03/02/obituaries/edwin-h-land-is-dead-at-81-inventor-of-polaroid-camera.html>.

exhausting huge amounts of time, money and other resources. Due to the risk of escalation of commitment to patented prospects, modeling patents and research and development projects using real options logic must take the characteristics of decision making into account in order to adequately describe the role of patents in innovation and technology commercialization.

Part I of this Article summarizes the incentive functions of the US patent system to place the commercialization behavior of a patent owner into the context of his right to exclude others.

Part II introduces the real options logic model of research and development projects and then extends the logic to patents by describing the costs a patent owner must weigh in order to determine (1) whether to obtain the option to exclude others by seeking patent protection and (2) whether to exercise the option through leverage, litigation, or licensing of the patent. A "file early, file often" mentality among inventors arises as a consequence of the US patent system rules and the value to be found in the exclusive rights granted by patents through litigation, licensing, and leverage.¹¹ On the one hand, encouraging early filing results in more competitive patent races between rivals, with earlier and earlier patent filing dates. This should result in earlier patent expiration dates and introduction of the patented technology into the public domain sooner.¹² On the other hand, expensive patent races may cause investors in patents to decline exercising the option to leverage and to enforce the patent, introducing the risk of underdeveloped patented technology.¹³

Part III describes the escalation of commitment to a failing course of action, a behavioral phenomenon observed in decision making under uncertainty. When firms receive ambiguous or negative feedback regarding a course of action with large previous investments, often companies continue to invest, "throwing good money after bad."¹⁴ Escalation of commitment occurs when a company considers sunk costs as relevant to a project. Not having made peace with its losses, a company switches from risk aversion to risk seeking in order to attempt to recoup the sunk costs. In the context of technology investments and the innovation process, companies suffering from a bias toward salient sunk costs continue to invest in and pursue patent protection on technology with uncertain technical

11. See Cotropia, *Folly*, *supra* note 7, at 69-70.

12. *Id.*

13. *Id.*

14. The phrase "throw good money after bad" means "to spend more money on something that has already failed." CAMBRIDGE DICTIONARY OF AMERICAN IDIOMS 275 (2003).

or commercialization success. Part III concludes by discussing the role that patents play in the escalating commitment phenomenon. In particular, this Part suggests that modeling patents in addition to research and development projects as a series of real options lack the ability to capture the escalating phenomenon. Because a company may prefer to escalate despite uncertainty, assumptions regarding abandonment or delay of the project are unreliable. When escalation of commitment influences decisions, underdevelopment may not occur.

Part IV discusses the upside and downside of escalation of commitment, including successes despite uncertainty and predictable failures, which may be perceived as either wasteful or socially productive despite private losses. In this Part, the Article further proposes countermeasures to enhance learning from escalation behavior in ways that feed back into the patenting process itself. By embracing and learning from both successes and failures rather than “throwing good money after bad,”¹⁵ patent owners may achieve a better investment strategy for high-risk, high-reward technology, which in turn will help to introduce new technologies and to expand innovation’s frontiers outward.

I. INCENTIVES TO INNOVATE: AN OVERVIEW

The US Constitution’s Intellectual Property Clause grants Congress the power to promote the progress of the useful arts by giving limited exclusive rights in discoveries to inventors.¹⁶ From its inception in 1790, scholars have described the patent system in utilitarian terms as providing incentives to innovate in exchange for limited rights to exclude.¹⁷ More particularly, the patent system functions both *ex ante* to entice innovation with the promise of future exclusion of others and *ex post* to encourage commercialization of patented inventions by providing patents of sufficient strength or breadth to attract capital.¹⁸ In so doing, patents provide private benefits to the patent owner in the form of limited but exclusive

15. *Id.*

16. U.S. CONST. art. I, § 8, cl. 8.

17. See CRAIG ALLEN NARD & R. POLK WAGNER, PATENT LAW 7, 19 (2008) (characterizing patent law as “designed to enhance social welfare through the production of and access to innovations”); see also *Graham v. John Deere Co.*, 383 U.S. 1, 9 (1966).

18. See generally F. Scott Kieff, *IP Transactions: On the Theory & Practice of Commercializing Innovation*, 42 HOUS. L. REV. 727, 732-36 (2005) (discussing methods to bridge the “valley of death” between innovation and commercialization); Mark A. Lemley, *Ex Ante versus Ex Post Justifications for Intellectual Property*, 71 U. CHI. L. REV. 129, 129 (2004) (cautioning against the applicability of an *ex post* justification such as prospect and public goods theories).

rights. Patents also provide public benefits, including innovation advancement and information disclosure through the public domain patent document.¹⁹

Such private and public benefits are not costless, however. The patent system incurs large administrative costs in the form of the United States Patent and Trademark Office (USPTO), which examines applications, issues patents, and manages the rules applicable to patent procurement and maintenance.²⁰ The patent system's grant of exclusive rights to private parties also creates the potential for deadweight loss in the form of output restriction by patent owners as well as the potential for patent races between rivals, which results in considerable expenditures prior to obtaining patent protection.²¹ Both of these are important societal costs.²² By balancing these costs with the benefits to society and to patent owners, the patent system exists on the premise that the resulting promotion of progress justifies the price society pays.²³

Granting a patent, however, does not promote progress standing alone. The USPTO examines and issues patents on new and useful *inventions*,²⁴ but the job is left to the patent owner to develop

19. JAMES BESSEN & MICHAEL J. MEURER, PATENT FAILURE 216 (2008).

20. 35 U.S.C. §§ 1-2 (2006).

21. On some of the costs of output restriction, see T. Randolph Beard et al., *Quantifying the Cost of Substandard Patents: Some Preliminary Evidence*, 12 YALE J.L. & TECH. 240 (2009), for an examination of the deadweight losses that result from granting substandard patents. On the costs of races to invent, see Yoram Barzel, *Optimal Timing of Innovations*, 50 REV. ECON. & STAT. 348 (1968), for a model of competition among firms to innovate. Barzel's model suggests that competition introduces innovations earlier than is optimal, creating a "basic wasteful effect . . . [that] lies not in duplicating the use of resources but in using these resources prematurely, when they would have earned a higher return elsewhere in the economy." *Id.* at 352. Duffy characterizes these competitions to innovate as "inefficient races to invent that can dissipate any social surplus associated with an invention." John F. Duffy, *Rethinking the Prospect Theory of Patents*, 71 U. CHI. L. REV. 439, 439 (2004).

22. *Id.*

23. Of course, as noted by William Landes and Richard Posner, "whether the benefits exceed the costs is impossible to answer with confidence on the basis of present knowledge." WILLIAM M. LANDES & RICHARD A. POSNER, THE ECONOMIC STRUCTURE OF INTELLECTUAL PROPERTY LAW 310 (2003); see FRITZ MACHLUP, AN ECONOMIC REVIEW OF THE PATENT SYSTEM 20-21 (1958) (describing the four best-known theories as "natural law," "reward-for-monopoly," "monopoly-profit-incentive," and "exchange-for-secrets" theses). Machlup—who famously declared that establishing a new patent system, if none existed, would be irresponsible based upon our lack of economic justification—then turned around and declared that abolishing our current patent system would also be irresponsible. MACHLUP, *supra*, at 80. For a detailed analysis of the nineteenth century patent abolitionist movement in the context of informing current patent law reforms, see Mark D. Janis, *Patent Abolitionism*, 17 BERKELEY TECH. L.J. 899 (2002).

24. 35 U.S.C. § 101. Invention refers to the discovery of new technology; innovation, on the other hand, refers to the introduction of new technology to the marketplace. See OFFICE OF TECH. ASSESSMENT, U.S. CONG., OTA-BP-ITC-165, INNOVATION AND COMMERCIALIZATION OF

the technology, alone or in combination with complementary technologies, and to deliver a new product or process to the marketplace. In order to do so, the patent owner or its licensees must expend scarce resources, which could be used in other lines of research or on other commercial endeavors. The utilitarian nature of the patent system lends itself to two different functions that relate to incentivizing innovation: incentivizing invention and incentivizing commercialization.

A. Patents as Incentives to Invent

The traditional view of patents as providing private value through exclusive rights may best be described as a reward function.²⁵ The possibility of obtaining the right to exclude others from making, using, offering for sale, selling, or importing into the United States any patented invention gives the patent owner an incentive to engage in creating an invention.²⁶ Potential patent owners may treat the right to exclude as a private reward for inventing.²⁷ The right to exclude also entices the inventor to disclose his invention to the public by virtue of the public domain patent document.²⁸ Taken as a whole, the patent system's reward function has been very persuasive in courts and in literature as a justification for patents, being cited as "an efficient method of enabling the benefits of research and development to be internalized, thus promoting innovation and technological progress."²⁹

EMERGING TECHNOLOGY 2 (Sept. 1995) (defining innovation, invention, and commercialization); JOSEPH A. SCHUMPETER, *THE THEORY OF ECONOMIC DEVELOPMENT* (1934); Robert P. Merges, *Commercial Success and Patent Standards: Economic Perspectives on Innovation*, 76 CALIF. L. REV. 805, 845 (1988) (describing the economics of innovation according to Joseph Schumpeter); Michael J. Meurer, *Inventors, Entrepreneurs, and Intellectual Property Law*, 45 HOUS. L. REV. 1201, 1209-13 (2008) (distinguishing innovation and invention by small firms).

25. See Clarisa Long, *Patent Signals*, 69 U. CHI. L. REV. 625, 632-33 (2002) (describing in detail this "simple view" of the patent system and suggesting a model of patents as a signaling mechanism to convey information); see also Stanley M. Besen & Leo J. Raskind, *An Introduction to the Law and Economics of Intellectual Property*, 5 J. ECON. PERSP. 3, 8 (1991).

26. See *Kewanee Oil Co. v. Bicron Corp.*, 416 U.S. 470, 480 (1974) ("The patent laws promote . . . progress by offering a right of exclusion for a limited period as an incentive to inventors to risk the often enormous costs in terms of time, research, and development."). See generally 35 U.S.C. § 271 (defining patent owner's right to exclude).

27. Besen & Raskind, *supra* note 25 ("The patent offers the incentive of the statutory right to exclude as a means for inducing creative activity.")

28. "In return for the right of exclusion—this 'reward for inventions,'—the patent laws impose upon the inventor a requirement of disclosure." *Kewanee*, 416 U.S. at 480 (citation omitted) (citing *Universal Oil Co. v. Globe Co.*, 322 U.S. 471, 484 (1944)).

29. LANDES & POSNER, *supra* note 23, at 294; see *Kewanee*, 416 U.S. at 480.

Each of these reward theories derives from the perception that too few inventors would make or disclose their inventions publicly without patent protection; the inventor's competitors who do not share in research and development costs may easily appropriate the invention.³⁰ Once competitors quickly imitate successful inventions, the price of the resulting product or process will move quickly toward a competitive level, leaving the original inventor unable to gain enough value from the invention to offset his irreversible costs of discovering and developing the invention.³¹ Moreover, the uncertain outcome associated with high-risk projects may increase the probability of underinvestment prior to commercialization.³² To overcome these hurdles to innovation, patent owners obtain the right to exclude others from practicing the invention, which provides the ability, in many cases, to exceed free-market levels of private return.³³ To enhance the public benefits obtained in exchange for the patent owner's right to exclude, patent procurement rules require disclosure of the invention in enough detail "as to enable any person skilled in the art to which it pertains . . . to make and use the same."³⁴

The reward function invites several points of objection. First, the output restriction inherent in providing exclusive rights has the potential to encourage monopoly pricing by the patent owner.³⁵ Without resorting to such output restriction, traditional methods for incentivizing investment may be sufficient to encourage invention, including first mover advantages, lead time delays, know how, and the like.³⁶ Second, patent incentives may alter economic activity by

30. This is often referred to as the "appropriability problem" that the patent system hopes to solve. See Kenneth W. Dam, *The Economic Underpinnings of Patent Law*, 23 J. LEGAL STUD. 247, 247 (1994) (arguing that the patent system has minimized the impact of its inefficiencies); John S. Leibovitz, *Inventing a Nonexclusive Patent System*, 111 YALE L.J. 2251, 2257 (2002) (addressing whether the patent system goes too far in solving the appropriability problem by granting too much appropriability); Gideon Parchomovsky & R. Polk Wagner, *Patent Portfolios*, 154 U. PA. L. REV. 1, 12-13 (2005) (pointing out flaws in the appropriability story due to a paradox in patent value).

31. See Rebecca S. Eisenberg, *Patents and the Progress of Science: Exclusive Rights and Experimental Use*, 56 U. CHI. L. REV. 1017, 1025 (1989) (citing MACHLUP, *supra* note 23, at 58-59).

32. *Id.*

33. *Id.* at 1025. Such returns above market value may be referred to as supracompetitive returns. *Id.*

34. See 35 U.S.C. § 112 (2006) (requiring that applicants disclose the invention in enough detail to allow someone skilled in the art to practice the invention, commonly known as the enablement requirement); *Kewanee Oil Co. v. Bicron Corp.*, 416 U.S. 470, 480-81 (1974).

35. See Eisenberg, *supra* note 31, at 1025-27.

36. *Id.* at 1026-27; see also Jonathan M. Barnett, *Private Protection of Patentable Goods*, 25 CARDOZO L. REV. 1251, 1254-56 (2004) (challenging the incentives theory (reward function) with empirical evidence describing private patent protection mechanisms, including first-mover

encouraging patent races among rivals, with each company spending resources on early development in order to win valuable patents.³⁷ Once a company wins a patent, future innovators may avoid the patent's domain and refrain from improvements to the patented invention, even if those improvements are valuable contributions to technology and patentable in their own right.³⁸ Third, patent owner infringement actions may cause duplicative efforts from rivals seeking to design around the patent claims.³⁹ With regard to the reward for disclosure, critics object on the grounds that the alternative, keeping the invention a secret, may not be a practical strategy for the inventor and thus he does not need a patent to effect disclosure.⁴⁰ Finally, if an invention may be practiced in secret, then infringement may occur in secret, making enforcement impossible for a patent owner.⁴¹

B. Patents as Incentives to Commercialize

Although the reward function of patenting remains popular,⁴² scholars have observed another role of the patent system—rewarding the commercialization of an invention after it has been made. Scholars associate the idea that patents incentivize commercialization in addition to invention with a “prospect function” of patents.⁴³ Recognizing that intense rivalry exists among potential innovators,

advantages, copy protection, contracts and industry norms, and proposes a market-entry theory as a normative justification for the patent system).

37. See Eisenberg, *supra* note 31, at 1026-28.

38. *Id.* at 1027.

39. *Id.* at 1027-28.

40. DONALD S. CHISUM ET AL., PRINCIPLES OF PATENT LAW: CASES AND MATERIALS 68 (5th ed. 2011).

41. *Id.*

42. See generally Lemley, *supra* note 18, at 149 (advocating for the reward theory as a more principled justification for the patent system).

43. See Edmund W. Kitch, *The Nature and Function of the Patent System*, 20 J.L. & ECON. 265, 266 (1977). In this widely cited paper, Kitch first argued that the patent system functions not just to “enable[] an inventor to capture the returns from his investment in the invention”—now commonly known as the reward function—but also “to increase the output from resources used for technological innovation,” which Kitch termed the prospect function. *Id.* at 265-66. Kitch’s “prospect theory” has become standard reading for students of patent law, and has inspired debates both for and against his propositions regarding the functions of a patent system. See Duffy, *supra* Note 21. At 440-42 (highlighting both supporters and critics of Kitch’s “controversial” arguments). Compare Mark Lemley, *The Economics of Improvement in Intellectual Property Law*, 75 TEX. L. REV. 989, 1045-46 (1997) (describing Kitch’s article as “one of the most significant efforts to integrate intellectual property with property rights theory”), with Roger L. Beck, *The Prospect Theory of the Patent System and Unproductive Competition*, 5 RES. L. ECON. 193, 194 (1985) (undermining belief in the prospect theory). For a critique of the prospect function, see Donald G. McFetridge & Douglas A. Smith, *Patents, Prospects and Economic Surplus: A Comment*, 23 J.L. & ECON. 197 (1980).

the prospect function suggests that granting a broad exclusive property right at an early stage in the innovation process should limit competitive rivalry.⁴⁴ The promise of private rewards encourages inventors to invent and then the *prospect* of further commercialization provided by a patent reduces the competitive dissipation of these returns by rivalry. The patent owner who wins the race to the patent office and thus obtains the first patent rights in an inventive area then may use those rights to manage development of the patent's value by himself and others, reducing duplicative investment in innovation and thereby improving social welfare.⁴⁵

By focusing on patent owners' channeling capabilities rather than the elimination of rivalry, the prospect features of the patent system could work to guide commercialization in ways that maximize the social benefits received from the grant of exclusive rights.⁴⁶ If inventors analogize these early patent races to auctions for the broad right to exclude others,⁴⁷ they may improve their chances of winning patent races (and of obtaining exclusive rights) by investing earlier and earlier in the patenting process.⁴⁸ The competitor who publicly discloses his invention at the earliest time wins the patent race.⁴⁹ If patent policy allows for patenting of incipient technology, the public benefits from an earlier expiration date for the patent⁵⁰ and, at the same time, the private and social costs of rivalry go down due to reduced spending on early-stage development and duplicative innovation efforts.⁵¹

Apart from incentivizing commercialization through the early granting of broad patent rights—whether because of reduced rivalry

44. See Kitch, *supra* note 43, at 276 (responding to Barzel's demonstration of inefficiencies from rivalry to invent as causing dissipation of social surplus); see also Barzel, *supra* note 221.

45. Kitch, *supra* note 43, at 276.

46. See Duffy, *supra* note 21, at 444-45. Duffy describes Kitch's comparison of the patent system to a mineral rights system "as a very imperfect analogy for the patent system," and likens the patent system to Harold Demsetz's proposal for regulating natural monopoly industries. *Id.* In such natural monopolies, where "a single firm can serve the entire market more efficiently than multiple competing firms can," Demsetz recognized "that private competition could be harnessed to accomplish the same objective as government price regulation" by auctioning the exclusive franchise to introduce competition on price and quality. *Id.* at 445.

47. *Id.*

48. *Id.* at 443-45.

49. *Id.* at 445. Duffy recharacterizes the prospect function as a question of "not *whether* rents will be dissipated, but *how* they will be dissipated." *Id.* at 443 (emphasis added).

50. *Id.* The patent will expire earlier because it is filed earlier than it would have been filed had a race to invent and patent not taken place between rivals. Accordingly, the patent term of twenty years measured from the effective filing date of the patent application begins running the earlier in time the patent owner files for a patent.

51. *Id.*

rent dissipation or because of early patent expiration—the patent’s right to exclude is “a Coasian-type property right placed on the public’s auction block by the government.”⁵² “The downstream commercialization [of a patented invention] requires coordination among the many complementary users . . . including, inter alia, developers, manufacturers, laborers, managers, investors, advertisers, and marketers.”⁵³ A private property system, complete with the right to exclude others, facilitates this coordination; the patent serves as a beacon for these users, helping them find each other to negotiate the rights needed for efficient bargaining.⁵⁴ Patent claims, the metes and bounds of the patented invention, provide public notice of the patent owner’s exclusive rights to all parties involved in the market for that technology, who will bargain to an efficient result—the company best suited to bring the patented invention to market will do so.⁵⁵

What happens when commercialization requires improvements to the patented technology? Since a broad initial patent comprises a right to exclude, not an affirmative right to practice the invention,⁵⁶ an inventor may patent improvements to a patented technology, provided that the improvements are useful, novel, and not obvious.⁵⁷ As a result, competition for exclusive rights to a technology may continue after the USPTO grants a patent because the patent owner and the patent owner’s rivals search for and patent, if possible, improvements to the original technology.⁵⁸ Rival improvers also “have an incentive to contract with the pioneer[ing patent owner] prior to investing in” commercialization efforts or in unpatentable improvements.⁵⁹ In the case of unpatentable improvements, “the prospect [function] applies without qualification: The pioneer can coordinate, and control the timing of, all investment in [un]patentable improvements on the patented technology.”⁶⁰ For example, the pioneer who invents an

52. CHISUM ET AL., *supra* note 40, at 69.

53. Kieff, *supra* note 18, at 735.

54. *Id.*

55. *Id.* at 735-36.

56. See F. Scott Kieff & Troy A. Paredes, *The Basics Matter: At the Periphery of Intellectual Property*, 73 GEO. WASH. L. REV. 174, 198 (2004) (“[P]atents only give a right to exclude. The right to use is derived from sources external to IP law.”). *But see* Adam Mossoff, *Exclusion and Exclusive Use in Patent Law*, 22 HARV. J.L. & TECH. 321 (2009) (recommending a more expansive view to include use and disposition).

57. For the applicable statutory provisions for patentability, see 35 U.S.C. §§ 101 (utility), 102 (novelty) and 103 (non-obviousness).

58. Duffy, *supra* note 21, at 483.

59. *Id.* at 486.

60. *Id.* (noting that “coordination increases the efficiency with which the investment can be made”).

innovative radiant heater can coordinate the manufacture of a paving machine utilizing the heater to improve the quality of asphalt pavement.⁶¹ The manufacturer of the improved paving machine, an infringer of the patented technology, must obtain permission from the pioneer in order to develop his machine improving upon the patented technology.⁶²

In contrast, patentable improvements are common rights available to any inventor, not just the pioneering patent owner.⁶³ Therefore, the fear of entry by competitors may drive a pioneering patent owner to quickly patent improvements himself or to coordinate the efforts of others in such improvements.⁶⁴ For example, a pioneer who invents an active ingredient drug with a special coating that prevents degradation of the drug before it reaches its intended interaction site will have an incentive to create follow-on inventions such as an embodiment with a second coating that exhibits improved delivery of the drug *in vivo*.⁶⁵ If the pioneer does not invest in improvements, he may find himself subject to patents obtained by others, requiring negotiation for the rights to those improvements that are commercially or technologically superior to his pioneer technology.

II. PATENTS AND REAL OPTIONS LOGIC

As discussed above, providing incentives to invent and commercialize useful, novel, and non-obvious technology has traditionally justified the patent system.⁶⁶ Apart from being a reward, the right to exclude others may channel competition into accelerated patenting, which could have positive externalities when earlier patent

61. See *Anderson's-Black Rock, Inc. v. Pavement Salvage Co.*, 396 U.S. 57, 58 (1969). In *Anderson's-Black Rock*, the Court declared the patent invalid on the grounds that it was obvious in view of the pioneering patent on the innovative radiant heater in combination with the elements of a known paving machine. *Id.* Improvements that are obvious over prior technology are unpatentable per 35 U.S.C. § 103. See *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 416-17 (2007) (discussing, *inter alia*, *Anderson's-Black Rock* and the obviousness standard required by § 103).

62. Duffy, *supra* note 21, at 486.

63. *Id.* at 489.

64. *Id.*

65. See *In re Omeprazole Patent Litig.*, 536 F.3d 1361 (Fed. Cir. 2008). In *Omeprazole*, the court determined that a second coating was not an obvious improvement to the underlying prior patent comprising a single coating of the drug omeprazole (brand name Prisolect®). *Id.* In its 2010 *KSR* Guidelines Update, the USPTO describes the *Omeprazole* case in detail to instruct examiners and the public as to the obviousness inquiry under § 103. See Examination Guidelines Update: Developments in the Obviousness Inquiry After *KSR v. Teleflex*, 75 Fed. Reg. 53,643, 53,646 (Sept. 1, 2010).

66. Duffy, *supra* note 21, at 488.

terms expire, and as a result of earlier filing,⁶⁷ transfer the patented technology to the public domain. Moreover, the right to exclude and the public disclosure function operate to coordinate commercialization through bargaining among potential stakeholders. The process of obtaining a patent and the patent owner's subsequent decisions to commercialize (or not) the technology has been modeled using real options logic to better capture the value of patent protection.

A real option, like an ordinary stock option, features a purchase of rights that the purchaser may exercise later.⁶⁸ Real options logic, also known as real options reasoning, models potential firm investments as real options in order to make strategic resource allocation decisions for the firm.⁶⁹ Modelers have used real options logic to describe the patent as an option to exclude others from practicing the patented technology.⁷⁰ A patent owner exercises the option to exclude others by commercializing the invention, negotiating with others for licenses, and enforcing the patent against infringers through litigation.⁷¹ Of course, the patent owner may decline to exercise the option, never excluding others, or delay in order to gather more information to inform the decision to exercise the option.⁷² Using this framework, early patent filing, as a result of the US patent procurement rules, creates a potential for underdevelopment of patented technology. In option terms, the option price for the patent is too low compared to the exercise price, given the uncertainty inherent in exercise and the shortened expiration period in such cases. Part II.A describes the real options logic framework as applied to patents. Part II.B discusses the concern for underdevelopment in the context of the real option framework.

67. See *supra* note 50.

68. Rita Gunther McGrath et al., *Real Options as Engines of Choice and Heterogeneity*, 29 ACAD. MGMT. REV. 86, 86-89 (2004).

69. *Id.*; see Ron Adner & Daniel A. Levinthal, *What is Not a Real Option: Considering Boundaries for the Application of Real Options to Business Strategy*, 29 ACAD. MGMT. REV. 74, 75 (2004) (explaining that real options feature “sequential, irreversible investments made under conditions of uncertainty”). In general, an option creates value by generating future rights in decisions made by the option holder. Adner & Levinthal, *supra*, at 75-76.

70. See Cotropia, *Real Options*, *supra* note 7, at 1137.

71. See *id.* at 1137-38 (describing exercise of the option as involving exclusion of others from making, using, selling, or offering for sale the invention); see also Martin & Partnoy, *supra* note 7.

72. Cotropia, *Real Options*, *supra* note 7, at 1132; see Abramowicz, *supra* note 7, at 1075-76. When the patent owner delays exercise of the option, he may be doing so to gain greater certainty as to the value of the right to exclude. Abramowicz, *supra* note 7, at 1075-76.

A. Real Options Logic

Options are mechanisms through which firms reduce the strategic risk of making commitments. In general, an option creates value by generating future rights in decisions made by the option holder.⁷³ An investment in a financial option purchases the right, but not the obligation, to either buy or sell an underlying asset at some point in the future.⁷⁴ By analogy, an investment in a real option conveys the right, but not the obligation, for a firm to make, defer or abandon further investments in a project or a course of action.⁷⁵ Like financial options, real options are “a limited commitment that creates future decision rights.”⁷⁶ Real options logic involves modeling potential investments as real options in order to make decisions regarding strategic resource allocations.⁷⁷ Real options logic allows the firm to treat a venture of uncertain future value as a complex option that incorporates the variables underlying the value of the venture.⁷⁸ This approach has been successfully used to value natural resources, oil leases, and other real assets.⁷⁹

Likewise, when approaching research and development projects, some firms prefer to use real options as a heuristic for making decisions on sequential investments in uncertain technology. In this way, abandonment or delay remains an option as the firm collects more information about the technology in hopes of resolving the uncertainty.⁸⁰ The value of research and development is almost

73. Cotropia, *Real Options*, *supra* note 7, at 1129; *see* Adner & Levinthal, *supra* note 69.

74. Literature often describes options as the right, but not the obligation, to do something. *See, e.g.*, F. Russell Denton & Paul J. Heald, *Random Walks, Non-Cooperative Games, and the Complex Mathematics of Patent Pricing*, 55 RUTGERS L. REV. 1175, 1195 (2003).

75. *See* Cotropia, *Real Options*, *supra* note 7, at 1129; Rita Gunther McGrath & Atul Nerkar, *Real Options Reasoning and a New Look at the R&D Investment Strategies of Pharmaceutical Firms*, 25 STRATEGIC MGMT. J. 1, 2 (2004) (using real options theory to describe how investors make decisions with regards to investments in research and development); Asghar Zardkoobi, *Do Real Options Lead to Escalation of Commitment?*, 29 ACAD. MGMT. REV. 111, 111 (2004) (describing real options as “toehold investments designed to better prepare the investor to meet uncertain events in the future”); Arvids A. Ziedonis, *Real Options in Technology Licensing*, 53 MGMT. SCI. 1618 (2007).

76. McGrath et al., *supra* note 68, at 86.

77. *Id.* at 86-87; *see* Adner & Levinthal, *supra* note 69, at 75 (noting that real options feature “sequential, irreversible investments made under conditions of uncertainty”).

78. *See* Eduardo S. Schwartz, *Patents and R&D as Real Options*, 33 ECON. NOTES 23, 24 (2004).

79. *Id.* (citing M.J. Brennan & E.S. Schwartz, *Evaluating Natural Resource Investments*, 58 J. BUS. 135 (1985); James L. Paddock et al., *Option Valuation of Claims on Real Assets: The Case of Offshore Petroleum Leases*, 103 Q. J. ECON. 479 (1988)).

80. Rita Gunther McGrath, *A Real Options Logic for Initiating Technology Positioning Investments*, 22 ACAD. MGMT. REV. 974, 976-77 (1997).

entirely calculated by option value; conventional valuation methods like the discounted cash flow model fail to adequately value research investments.⁸¹ Real options logic is an alternative approach that takes into account the firm's options to invest, abandon, or delay the project when determining the desirability of the research and development project to the firm over time.⁸²

When companies model research and development projects as real options, patents obtained on the resulting technology often play an important role in calculating the value of the options, and therefore, the project.⁸³ For example, companies use real options logic to determine, before investment starts, the value of pharmaceutical research and development projects and the patents protecting them.⁸⁴ A real options model of pharmaceutical research and development and patents must take into account the investment costs and expected cash flows as a result of the investment.⁸⁵ In the case of pharmaceuticals, cash flows from an approved drug.⁸⁶ Patents play a relevant role in the duration and size of both investment costs and future cash flows and thus play an integral part in valuation of the overall project.⁸⁷

Conceptually removed from the long-term research and development project, companies also model the patent instrument as a real option itself. Most commonly, companies borrow from financial option pricing theory and utilize real options to determine patent pricing in the context of asset valuation or licensing decisions.⁸⁸ For

81. Ming-Cheng Wu & Chun-Yao Tseng, *Valuation of Patent—A Real Options Perspective*, 13 APPLIED ECON. LETTERS 313, 314 (2006).

82. *Id.*

83. Schwartz, *supra* note 78, at 46-47. See generally Mark Schankerman, *How Valuable is Patent Protection? Estimates by Technology Field*, 29 RAND J. ECON. 77 (1998).

84. Schwartz, *supra* note 78, at 45. Schwartz discusses incorporation of patent policy changes into his real options model of pharmaceutical research and development projects to reflect entry of competitors as a result of Hatch-Waxman patent term extension or to reflect a change in patent term overall. *Id.* He also mentions the limitations of using patents to determine timing of cash flows without accounting for litigation and unenforceability concerns, noting that "the reality is that there is much more fuzziness around these patent issues" than found in his simplistic model. *Id.*

85. *Id.*

86. *Id.*

87. *Id.* at 25.

88. See, e.g., Denton & Heald, *supra* note 74 (developing a variant of the Black-Scholes equation for valuing stock options in order to price patent licenses modeled as real options). The Black-Scholes option pricing model has been used to establish prices for patents. See *id.* at 1213; Lauren Johnston Stiroh & Richard T. Rapp, *Modern Methods for the Valuation of Intellectual Property*, 532 PLI/PAT 817 (1998). For further explanation of the Black-Scholes model, see Fischer Black & Myron Scholes, *The Pricing of Options and Corporate Liabilities*, 81 J. POL. ECON. 637 (1973); Fischer Black & Myron Scholes, *The Valuation of Option Contracts and a Test*

example, an intellectual property holding company may use a common financial option pricing model to identify an appropriate royalty rate for a license of its patent portfolio by taking into account the present value of the technology's expected cash flows, the present value of the investment cost, the time until expiration of the patent, a risk-free rate of interest, and the uncertainty of the underlying technology over time.⁸⁹ Financial option pricing models require several assumptions that limit their application to robust patent valuation—assumptions that are strained in the context of patent licensing where markets are not liquid and pricing is not continuously adjusting—but the application of financial options pricing theory has advanced the state of the art of patent valuation.⁹⁰

More recently, scholars have extended real options logic from valuation to the patent policy realm.⁹¹ Patents involve a great deal of uncertainty as to the value of its right to exclude others, i.e., concerns about the patent's scope, validity, and enforceability. These uncertainties lend toward modeling the patent instrument as a real option to exclude others, including the right to exercise, delay, or abandon the option up and until the patent expires.⁹² The flexibility inherent in modeling decisions with real options logic lends itself to the uncertainty of patent scope and enforceability in the same manner as it does to research and development projects of uncertain viability.

of *Market Efficiency*, 27 J. FIN. 399 (1972); Robert C. Merton, *Theory of Rational Option Pricing*, 4 BELL J. ECON. & MGMT. SCI. 141 (1973). Merton and Scholes were awarded the 1997 Nobel Prize in Economics for the dynamic option pricing theory captured by the Black-Scholes option pricing model, as Black passed away before the prize was awarded. Press Release, Nobelprize.org, The Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel 1997 (Oct. 14, 1997), available at http://www.nobelprize.org/nobel_prizes/economics/laureates/1997/press.html. Best-selling author Michael Lewis implicated the Black-Scholes model in the collapse of the subprime mortgage bond market because it "underestimated the risk of extreme and rare events." Michael Lewis, *Inside Wall Street's Black Hole*, PORTFOLIO.COM (Feb. 19, 2008), <http://www.portfolio.com/news-markets/national-news/portfolio/2008/02/19/Black-Scholes-Pricing-Model/index2.html>.

89. Fernando Torres, *Establishing Licensing Rates Through Options*, IP FRONTLINE (Sept. 11, 2006), <http://www.ipfrontline.com/depts/article.aspx?id=12586&deptid=3>. Torres uses the Black-Scholes option pricing model to establish the royalty rate for patent licenses. See Darius Kharabi, *A Real Options Analysis of Pharmaceutical-Biotechnology Licensing*, 11 STAN. J.L. BUS. & FIN. 201, 216-17 (2006). Kharabi describes the utility of option pricing in the context of biotechnology licenses as a "back-of-the-envelope calculation [that] provides a company with additional valuable insight into the license's value." *Id.* at 231.

90. See Denton & Heald, *supra* note 74, at 1204-05; Kharabi, *supra* note 89, at 217. Denton and Heald adapted the Black-Scholes model to deal with the special context of patent licensing by adjusting the assumptions and adding a negotiation component consistent with game theory. See Denton & Heald, *supra* note 74, at 1203.

91. Cotropia, *Real Options*, *supra* note 7; Partnoy & Martin, *supra* note 7.

92. Cotropia, *Real Options*, *supra* note 7, at 1131-32.

Patents modeled as real options require first a purchase decision then an exercise decision (or multiple similar exercise decisions as explained below); the patent owner should rationally compare the price of the option or the exercise thereof and determine whether he should proceed based on expected future revenue.⁹³ An inventive entity (whether an individual or company) must first buy the option by applying for and successfully obtaining the patent instrument from the USPTO.⁹⁴ The option price comprises the USPTO filing fees, preparation fees for the application, the pre-application cost of invention, and the cost of disclosure.⁹⁵ Although the filing fees are fixed by the USPTO and preparation fees may be relatively uniform across industries and perhaps within geographical regions, the cost of pre-application invention may be highly variable within the same industry and with regard to applications claiming similar subject matter. Due to the rigorous requirements of the Patent Act, an inventor may not obtain a patent unless the invention is new, useful, not obvious, within the categories of statutory subject matter, and properly disclosed.⁹⁶ Therefore, prior to applying for a patent, the inventor must expend resources *inventing*—time and capital devoted to developing the technology sufficiently to support a patent application that meets these requirements.⁹⁷ Obviously, this investment will vary among industries and technology arts, as well as among individual inventors.⁹⁸ Importantly, the timing of the filing of

93. This may not always be the case, as explained more fully *infra* in Parts III and IV.

94. Partnoy & Martin, *supra* note 7.

95. See Cotropia, *Real Options*, *supra* note 7, at 1135-37. The application fee required by the USPTO includes a base fee that increases if the application contains more than twenty claims total, contains more than three independent claims, or exceeds one hundred pages. 37 C.F.R. § 1.16(a), (i), (s) (2011). The American Intellectual Property Law Association (AIPLA) reports that the median amount charged by a patent professional to prepare an original utility patent application for a complex electrical case in 2008 was \$10,000, for a complex mechanical case \$9,000, and for a complex biotech case \$12,000. AM. INTELLECTUAL PROP. LAW ASS'N, REPORT OF THE ECONOMIC SURVEY 2009 25 (2009). An inventor may prosecute his application pro se. However, due to the credentials needed to competently prosecute a patent application, even the Federal Circuit has cautioned against this practice. See *Nilssen v. Osram Sylvania, Inc.*, 504 F.3d 1223, 1235 (Fed. Cir. 2007) (finding a pro se inventor's patents unenforceable due to inequitable conduct during prosecution). As the Federal Circuit noted, "[the pro se inventor], while apparently gaining considerable knowledge of the patenting process, thought he didn't need professional patent help. The result of this case, regrettably, proves that he was wrong." *Nilssen*, 504 F.3d at 1235.

96. See 35 U.S.C. §§ 101-103, 112 (2006) (providing for utility and eligible subject matter, novelty, non-obviousness, and proper disclosure, respectively).

97. Cotropia, *Real Options*, *supra* note 7, at 1135-36.

98. A "Eureka!" moment may be much less costly than a technology developed slowly and painstakingly over time. *Id.* at 1135 (citing Dan L. Burk & Mark A. Lemley, *Policy Levers in Patent Law*, 89 VA. L. REV. 1575, 1581-83 (2003)).

a patent application will influence the pre-application cost of invention in tangible ways. If the inventor files early in the development process but has not been involved in an expensive race to invent with competitors, the option price could be lower than if the patent applicant waited until later in the development process to file. However, if the inventor files early in the development process after engaging in (and winning) an expensive patent race, the option price could be many times higher than if the inventor had not raced to the patent office at all.

The cost of disclosure may be similarly difficult to quantify. In order to obtain a patent, the inventor must make a full and clear disclosure of the invention in his patent application.⁹⁹ When the patent issues (or earlier if the application is published within eighteen months of its filing),¹⁰⁰ “the public receives a meaningful disclosure in exchange for being excluded from practicing an invention for a period of time.”¹⁰¹ Accordingly, the Patent Act requires that the patent specification provide a written description of the invention and must “enable any person skilled in the art to which it pertains.”¹⁰² The cost to the patent applicant of disclosing to the public his invention in such specific terms—the quid pro quo for the right to exclude—comprises the cost of triggering the efforts of others to design around the invention or to develop patentable improvements on the invention. This cost could be the opportunity cost of choosing the patent regime over keeping the invention a secret.¹⁰³

In addition to a purchase price, the patent option must also have an exercise price, which requires an analysis of how the real option to exclude others is exercised by the patent owner. Three types of conduct by the patent owner exercise the option: leverage, litigation, and licensing.¹⁰⁴ Commercialization of the invention may be most

99. See 35 U.S.C. § 112 (prescribing the requirements of disclosure in order to obtain a patent).

100. 35 U.S.C. § 122(b)(1)(A).

101. Ariad Pharm., Inc. v. Eli Lilly & Co., 598 F.3d 1336, 1354 (Fed. Cir. 2010); see also J.E.M. AG Supply, Inc. v. Pioneer Hi-Bred Int'l, Inc., 534 U.S. 124, 142 (2001) (“The disclosure required by the Patent Act is ‘the *quid pro quo* of the right to exclude.’” (quoting *Kewanee Oil Co. v. Bicron Corp.*, 416 U.S. 470, 484 (1974))).

102. 35 U.S.C. § 112 (“The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same, and shall set forth the best mode contemplated by the inventor of carrying out his invention.”).

103. Cotropia, *Real Options*, *supra* note 7, at 1136-37.

104. Atul Nerkar & Ian C. Macmillan, *Giving Up Competitive Advantage: The Role of Learning in the Abandonment of Real Options* 7 (forthcoming), available at http://gsiaserver1.gsia.cmu.edu/seminars/docs/nerkar_paper.pdf.

identified with leveraging the patent, when a patent owner uses his right to exclude to “clear[] shelf space” for the patented technology.¹⁰⁵ Exercising the option in this manner requires that the patent owner expend additional time and resources internally to develop the technology into a commercially viable product or method.¹⁰⁶ If the patent applicant’s pre-application investment has been inexpensive, the cost of commercialization could be significant and vice versa.

In addition to leveraging the patent for profitable commercialization, patent owners may attempt to capture value from the right to exclude through litigation and licensing. Defined broadly, litigation by the patent owner may include enforcement threats or actual suits against infringers of the patent.¹⁰⁷ As a result of the wide range of conduct within this category, the costs of litigating the patent can range from inexpensive cease and desist letters to a very expensive full-blown patent suit that proceeds to final judgment.¹⁰⁸ Licensing may include either extracting rents from others or sharing in the commercialization by competing with licensees in the market for the patented technology.¹⁰⁹ Accordingly, the patent owner exercises his option by exploiting his right to exclude, by leveraging the patent to commercialize the technology, by licensing others to compete with him, by foregoing commercialization and licensing for revenue, and/or by litigating to obtain remedies from infringers.¹¹⁰

The value of the option will be limited in time because of the limited duration of patent rights—a patent ordinarily expires twenty years from the filing date of the application, which sets an absolute maximum duration for the option to exclude others.¹¹¹ The patent

105. Cotropia, *Real Options*, *supra* note 7, at 1137.

106. *Id.* at 1137-38.

107. Nerkar & Macmillan, *supra* note 104, at 8 (defining the option exercise as one of litigation, licensing, and leverage); *see also* Cotropia, *Real Options*, *supra* note 7, at 1138. Cotropia, citing Partnoy and Martin, identifies two different ways of exercising the patent: commercialization and assertion. Cotropia, *supra* note 7, at 1138. Because the real option value is in the patent’s right to exclude others from practicing the claimed invention, the option is exercised by the three types of conduct Nerkar and Macmillan describe—litigation, licensing, and leverage. Nerkar & Macmillan, *supra* note 104, at 7-8.

108. Cotropia, *Real Options*, *supra* note 7, at 1138-39. For patent infringement of more than \$25 million, AIPLA reports a median patent litigation cost (including attorneys’ fees) of \$5.5 million for litigation to final judgment, with an average cost of \$6.25 million and a third quartile cost of \$8 million for very complex patent cases. AM. INTELLECTUAL PROP. LAW ASS’N, *supra* note 95, at I-129.

109. Nerkar & Macmillan, *supra* note 104, at 8-9; *see* Cotropia, *Real Options*, *supra* note 7, at 1138-39; Partnoy & Martin, *supra* note 7.

110. Nerkar & Macmillan, *supra* note 104, at 7-9; *see* Cotropia, *Real Options*, *supra* note 7, at 1138-39.

111. Cotropia, *Real Options*, *supra* note 7 at 1139; *see* 35 U.S.C. § 154(a)(2) (2006) (setting the patent term).

may expire *de facto* if the right to exclude loses its value completely (for example, if non-infringing substitutes enter the market and compete effectively with the patented technology or if the substitute renders the patented technology obsolete).¹¹² The option itself will also expire if the patent is declared invalid or unenforceable by a federal court or by the USPTO in a reexamination proceeding.¹¹³ When determining the duration of the patent option, a patent owner must take into account not just the twenty-year term, but also the uncertainty inherent in the scope of the right to exclude others (i.e. how far will the right to exclude reach in its assertion?) and in the potential for invalidation if asserted in a manner that subjects the patent to challenge in court (i.e. will the patent be invalidated if it is asserted against this infringer?). The timing of expiration will influence whether the patent owner should exercise his option to leverage, litigate, or license the patented technology.

B. The Potential for Underdevelopment of Patented Technology

Modeling patents as real options, scholars have linked early filing by patent owners to a potential for underdevelopment of patented technology.¹¹⁴ In this view, because the rules for procuring US patents encourage earlier filing for patent protection, patent owners can buy the patent option inexpensively before any considerable development occurs. As the patent owner faces a shorter patent term, because the twenty-year patent term is tied to the application *filing* and not the development of a viable product, he may forego commercialization.¹¹⁵

112. Cotropia, *Real Options*, *supra* note 7, at 1139-40. Cotropia provides as an example the patented audiocassette technology, which was rendered obsolete by MP3 players and compact discs. *Id.* Exclusivity in the case of non-infringing substitutes or obsolete technology does not give the patent owner the ability to demand a supracompetitive price for his patented technology. *Id.* at 1140.

113. In contrast, Cotropia does not consider a declaration of invalidity or unenforceability for inequitable conduct to constitute an expiration of the option; instead, he prefers to treat invalid or unenforceable patents as unenforceable *ab initio*. *Id.* at 1141. However, patents are presumed valid until declared otherwise in court. See 35 U.S.C. § 282. A patent that has not been invalidated or declared unenforceable retains for its owner a valuable option to exclude others from practicing the invention, provided the patent is not blatantly invalid (such patents are also known as "scarecrow" patents). See *Bresnick v. U.S. Vitamin Corp.*, 139 F.2d 239, 242 (2d Cir. 1943) (invalidating an entire patent "because it has seemed to us proper that it should not remain in the art as a scarecrow"). Understandably, scarecrow patents will carry no option value, but surely this category of patents will be small if the USPTO examines patents with any level of rigor.

114. See Abramowicz, *supra* note 7, at 1073-74; Cotropia, *Folly*, *supra* note 7, at 111.

115. Abramowicz, *supra* note 7, at 1074; Cotropia, *Folly*, *supra* note 7, at 81.

The US patent procurement rules tend to encourage early filing in at least four ways. First, the novelty and obviousness requirements create a ticking clock; inventors have an incentive to file as early as possible in order to establish priority over other inventors or public disclosures that may render the subject matter anticipated or obvious.¹¹⁶ Second, courts interpret the disclosure requirement to allow for some experimentation by a skilled artisan carrying out the invention, which permits an inventor to provide an adequate disclosure without anticipating every detail of the invention's future implementation.¹¹⁷ Third, the inventor does not need to show any commercial viability to obtain a filing date, provided the invention is operable and useful in theory.¹¹⁸ Fourth, courts could reward early filers in priority disputes between putative inventors because courts recognize, as a constructive reduction to practice, the patent application filing that meets the disclosure requirement.¹¹⁹ Working together, these rules encourage an inventor to file an application for an invention that is not yet reduced to practice¹²⁰ but may be "ready for patenting,"¹²¹ pushing patent applicants to file earlier.¹²²

116. 35 U.S.C. § 102.

117. See *In re Wands*, 858 F.2d 731, 737 (Fed. Cir. 1988) (discussing § 112 as requiring a disclosure that teaches a skilled artisan "to make and use the invention without undue experimentation," despite this qualifying language not appearing in the statute).

118. See *Brenner v. Manson*, 383 U.S. 519, 529-30 (1966); *Juicy Whip, Inc. v. Orange Bang, Inc.*, 185 F.3d 1364, 1366 (Fed. Cir. 1999).

119. See ROBERT P. MERGES & JOHN F. DUFFY, *PATENT LAW & POLICY: CASES & MATERIALS* 452-53 (5th ed. 2011). Merges and Duffy also note that the availability of provisional applications under 35 U.S.C. § 111 has made constructive reduction to practice even easier and less expensive to achieve. *Id.* Although the current priority rules are a unique feature of the US first to invent patent system, recent passage of the America Invents Act (S. 23, H.R. 1249) switches to a first inventor to file system, which may further encourage early filing by creating a race to the patent office. See Cotropia, *Folly*, *supra* note 7, at 81-82. For more information on the first inventor to file system, see Press Release, US Senate, Understanding the America Invents Act—Right of the First Inventor to File (2011), available at <http://leahy.senate.gov/imo/media/doc/PRESS-FirstInventorToFile-OnePager-FINAL.pdf>.

120. The reduction to practice of the invention marks the point in time when the inventor recognizes that the invention works for its intended purpose. See *Corona Cord Tire Co. v. Dovan Chem. Corp.*, 276 U.S. 358, 383 (1928). The filing date of the application is considered a constructive reduction to practice, but inventors may establish earlier reductions to practice in order to win priority disputes or to antedate prior art cited against the application. See *Mahurkar v. C.R. Bard, Inc.*, 79 F.3d 1572 (Fed. Cir. 1996) (affirming judgment for patentee who proved an earlier reduction to practice to antedate prior art reference).

121. See *Pfaff v. Wells Elec., Inc.*, 525 U.S. 55, 67 (1998). Since the one year on sale bar of § 102(b) will be triggered by a commercial offer for an invention that is ready for patenting, it follows that inventors who have inventions ready for patenting will be under some pressure to file an application sooner rather than later if they have commercial prospects. *Id.* An invention's readiness for patenting may be demonstrated in at least two ways: (1) with evidence of an actual reduction to practice or (2) with evidence that the inventor has enough information to create the disclosure required by § 112 paragraph 1. *Id.* at 67-68.

Some public benefits of early filing may include the facilitation of commercialization and the earlier expiration of the patent identified by patent scholars Edmund Kitch, John Duffy, and others.¹²³ As a result, more patents are filed, examined, and issued.¹²⁴ Therefore, encouragement of early filing may feature some underappreciated costs, including inventors filing for too many patents because they are eager “to compensate for the lack of invention information at the early stage of development and to capture the new information encountered at later stages.”¹²⁵ Over-filing may result in further burdens on the USPTO, a decrease in the quality of patent applications overall, the promotion of “patent trolls,” and the creation of uncertain patent boundaries.¹²⁶ Of course, provided that the patent system works on some level, extra applications are not concerning per se—technology progresses, and worthless patents will not be enforced while valuable patents will be commercialized and/or enforced.¹²⁷ This account, however, assumes that the patent owner has perfect information about the patent’s value, which is not possible given the inherent uncertainty of patent scope and validity.

That earlier filing provides a strong incentive to commercialize makes for a compelling story because the patent owner can facilitate commercialization earlier and the technology enters the public domain earlier.¹²⁸ However, modeling the patent as a real option, where future information helps the patent owner make sequential decisions regarding whether and when to exercise its option to exclude others, crystallizes concerns about extremely early patent filing.¹²⁹ In fact, earlier patent filing makes it less likely that the patent owner ever

122. Cotropia, *Folly*, *supra* note 7, at 72-82. Cotropia identifies a lack of barriers to early filing, including: (1) no requirement that the invention be reduced to practice at the time of filing, (2) a lax utility requirement, and (3) incentives to file early, including a constructive invention date as of the filing date and a one-year bar to patentability measured from the filing date. *Id.* Cotropia describes Kitch as “the most notable champion of early filing” in reference to the prospect function. *Id.* at 82. Duffy also advocates for early filing as a way to push up the patent term to reduce social costs of such patent races. *See* Duffy, *supra* note 21, at 466-67; Kitch, *supra* note 43, at 270-71.

123. Cotropia, *Folly*, *supra* note 7, at 82-87 (identifying the facilitation of commercialization, reduction of wasteful rivalry later in the development process, and early expiration of the patent term); *see* Duffy, *supra* note 43, at 445; Kitch, *supra* note 21, at 266.

124. Cotropia, *Folly*, *supra* note 7, at 70.

125. *Id.* at 88.

126. *Id.*

127. *See* John R. Allison et al., *Valuable Patents*, 92 GEO. L.J. 435 (2004); Cotropia, *Folly*, *supra* note 7, at 107 (“If the early-filing doctrine leads to more of a good thing—that is, more technological progress—then the extra applications are not a concern.”).

128. *See* Duffy, *supra* note 21, at 445; Kitch, *supra* note 43, at 269-71.

129. *See* Cotropia, *Real Options*, *supra* note 7, at 1135-39; *see generally* Duffy, *supra* note 43; Kitch, *supra* note 21.

commercializes the patented invention.¹³⁰ Early ideas might be technologically unsound or commercially worthless but the patent owner may file anyway because of commercial *potential*.¹³¹ Subsequent to filing, the inventor identifies those patented technologies that are worth pursuing and those that are not, leaving many patented inventions on the cutting room floor.¹³² If patents represent an option to decide later whether the patent owner should exercise the option to leverage, litigate, or license the invention, then the purchase price (the application fee and the cost of invention needed to overcome the low barriers to patenting) limits the downside risk of commercialization, which has infinite upside potential.¹³³ This makes the deal of the patent too good to pass up; patenting requires few resources prior to filing, but requires large amounts of resources later to commercialize.¹³⁴ A small investment by the patent owner makes him less interested in commercialization and “more likely to ignore, and in turn devote less energy to pursuing, long-term interests.”¹³⁵ Similarly, early patent owners may forego commercialization precisely because of the shortened patent term. Fearing appropriation by others after the patent expires, the patent owner may perceive the shortened patent term as too short to adequately commercialize prior to the expiration of his right to exclude others.¹³⁶ If this is so, many owners may underdevelop patents or not develop them at all; in other words, it will not be worthwhile to the patent holder to exercise the option for full commercialization.¹³⁷

III. ESCALATING COMMITMENTS TO TECHNOLOGY

When using real options logic to describe patents and their commercialization, one assumes that the patent owner makes informed strategic decisions to delay, abandon, or enforce his right to exclude others.¹³⁸ In order for underdevelopment to occur as theorized, the patent owner must be willing to file early and file often,

130. Cotropia, *Folly*, *supra* note 7, at 107.

131. *Id.* at 108.

132. *Id.*

133. *Id.* at 108-09.

134. *Id.* at 110.

135. *Id.* at 111.

136. Abramowicz, *supra* note 7, at 1073.

137. *Id.* at 1073-74.

138. See, e.g., Abramowicz, *supra* note 7, at 1076-77 (discussing delay of commercialization and abandonment); Nerkar & Macmillan, *supra* note 104, at 11 (discussing information relevant to abandonment decision).

perhaps at great expense, taking into account the potential for patent races and early adversarial activity. He then must make crisp abandonment decisions without taking into account his previously sunk costs. Part III.A discusses the phenomenon of escalation of commitment to losing courses of action, which influences patented technology commercialization in ways that may actually encourage development where real options logic predicts underdevelopment. Although real options logic allows for a theoretical limit to downside risk and for abandonment by the options holder at any time, many technology firms may make decisions that are not in accordance with such logic.¹³⁹ Part III.B addresses the role that patents play in escalation.

A. Sunk Costs and Escalating Commitment

Individual inventors like Chester Carlson and large organizations like Xerox often face important dilemmas regarding whether to continue to invest in technology projects that involve a great deal of uncertainty.¹⁴⁰ Should the individual or organization discontinue an unproductive line of research or commit more time, effort, or resources into making the research and its subsequent development pay off?¹⁴¹ When project decision-makers face uncertainty in determining whether to continue forward with a losing course of action, in spite of its merits, it often leads to what has been described as an escalation of commitment.¹⁴² Researchers have described salient examples of escalation behavior: Couples persist in relationships that have deteriorated, a person at a bus stop waits much longer than it would have taken to walk to his destination, or a firm continues to invest in an unsuccessful technology.¹⁴³ In each of

139. See *infra* Part III.A.

140. See Glen Whyte, *Escalating Commitment to a Course of Action: A Reinterpretation*, 11 ACAD. MGMT. REV. 311, 311-12 (1986).

141. *Id.* at 311.

142. Glen Whyte, *Escalating Commitment in Individual and Group Decision Making: A Prospect Theory Approach*, 54 ORGANIZATIONAL BEHAV. & HUM. DECISION PROC. 430, 431 (1993). Escalation of commitment has been described by several names, including "too invested to quit," the sunk cost effect or bias, and entrapment. *Id.* In each case, the decision-maker tends to continue with the course of action once investments have been made, even if new information indicates the course of action has the potential to be a losing one. *Id.* at 430-31.

143. Joel Brockner, *The Escalation of Commitment to a Failing Course of Action: Toward Theoretical Progress*, 17 ACAD. MGMT. REV. 39 (1992). Another particularly salient example of escalation of commitment in the political sphere occurs in the context of wars and international conflicts. See Barry M. Staw & Jerry Ross, *Commitment to a Policy Decision: A Multi-Theoretical Perspective*, 23 ADMIN. SCI. Q. 40, 40 (1978) (citing Memorandum from George Ball to Lyndon Johnson (July 1, 1965), in PENTAGON PAPERS (Neil Sheehan ed., 1971)). In reference to the

these situations, “[c]ommitment tends to beget commitment, and investment to beget investment”¹⁴⁴ as decision-makers consider prior sunk costs relevant to future decisions.¹⁴⁵

The escalation of commitments phenomenon can be attributed to both objective characteristics of the project as well as behavioral factors associated with the decision-maker.¹⁴⁶ When accounting for objective characteristics about the project at hand, typically a decision-maker will withdraw from courses of action when the prospect of future outcomes becomes certainly and sufficiently bleak.¹⁴⁷ Indeed, escalation might not occur at all if the decision-maker has conspicuous and relevant information regarding the probabilities of future outcomes available to him.¹⁴⁸ But continuing a project in the face of setbacks, especially financial setbacks, is not always irrational. In order to make a decision to commit to or withdraw from a course of action, a decision-maker should consider whether negative feedback from the project is temporary or permanent, what effect continued investment will have on the future expected return on investment of the project, what further investment will add to future costs, whether the proposed investment will be

Vietnam conflict, a memorandum from Undersecretary of State George Ball to Lyndon Johnson warns of escalation effects: “Once we suffer large casualties . . . our involvement will be so great that we cannot—without national humiliation—stop short of achieving our complete objectives.” Staw, *supra*.

144. Jeffrey Z. Rubin et al., *Factors Affecting Entry into Psychological Traps*, 24 J. CONFLICT RESOL. 405, 406 (1980) (collecting citations).

145. Whyte, *supra* note 142, at 431. Whyte suggests that taking sunk costs into account “violates a fundamental tenet of standard economic rationality and can lead to normatively inappropriate choices.” *Id.* According to one view, decision-makers exhibit irrationality because they are engaging in “behavior not explained by either objective circumstances or standard economic decision-making.” Barry M. Staw & Jerry Ross, *Understanding Behavior in Escalation Situations*, 246 SCIENCE 216, 216 (1989) (citing ALLAN I. TEGER, TOO MUCH INVESTED TO QUIT (1980); Jeffrey Z. Rubin & Joel Brockner, *Factors Affecting Entrapment in Waiting Situations: The Rosencrantz and Guildenstern Effect*, 31 J. PERSONALITY & SOC. PSYCHOL. 1054 (1975); Barry M. Staw, *Knee-Deep in the Big Muddy: A Study of Escalating Commitment to a Chosen Course of Action*, 16 ORGANIZATIONAL BEHAV. & HUM. PERFORMANCE 27 (1976)). Another view proposes that escalation of commitment is rational because of information effects, financial or time constraints, or because the decision-maker takes into account the high costs of withdrawal, including psychological and social harms to the individual or organization such as reputational harms or embarrassment. Staw & Ross, *supra* (citing Gregory B. Northcraft & Gerrit Wolf, *Dollars, Sense, and Sunk Costs: A Life Cycle Model of Resource Allocation Decisions*, 9 ACAD. MGMT. REV. 225 (1984)). Staw and Ross suggest that this debate over rationality detracts from the effect itself, preferring to focus on the behavioral and economic factors that contribute to an escalation of commitment. Staw & Ross, *supra*.

146. Staw & Ross, *supra* note 145.

147. *Id.*; Itamar Simonson & Barry M. Staw, *Deescalation Strategies: A Comparison of Techniques for Reducing Commitment to Losing Courses of Action*, 77 J. APPLIED PSYCHOL. 419, 420 (1992).

148. Staw & Ross, *supra* note 145.

effective in turning the project around, and whether previous commitments of investment have failed to bring the project around.¹⁴⁹ The decision-maker also should consider timing, specifically whether delay is a normal part of the project.¹⁵⁰ In projects with long timeframes between initial costs and future benefits, such as research and development projects, early underperformances may not be monitored closely or projects with high termination costs and little salvage value may be allowed to continue without much investigation into future probability of success.¹⁵¹ Unfortunately, real-world decision-makers face much more ambiguous situations.¹⁵² When deciding whether to commit more resources, information regarding the value and probability of future returns may be ambiguous or completely lacking; the value and probability of future returns may depend on many unknown (and perhaps unknowable) factors.¹⁵³ The *perceived* value and probability of success affect a decision-maker's resource allocation decisions.¹⁵⁴ Without clear and salient information, an escalation tendency may result in a poor and costly decision. The value of future returns may intensify if past losses like sunk costs loom large, as discussed below.

In addition to these objective indicia, certain behavioral factors appear to influence the relevance of sunk costs when deciding to escalate commitments.¹⁵⁵ In the realm of psychological and social motivation, studies of commitment often emphasize self-justification bias—the decision-maker may be biased toward choices that justify his previous decisions.¹⁵⁶ A decision-maker may continue to invest in losing courses of action when he has a strong individual desire to make the correct decision or to convince himself or others that his decision is competent or rational.¹⁵⁷ Often, the decision-maker tries to make earlier failed decisions pay off by committing more resources to

149. *Id.*

150. Simonson & Staw, *supra* note 147.

151. Thomas S. Bateman, *The Escalation of Commitment in Sequential Decision-Making: Situational and Personal Moderators and Limiting Conditions*, 17 DECISION SCI. 33 (1986); Staw & Ross, *supra* note 145, at 216-17; Barry M. Staw & Fredrick V. Fox, *Escalation: The Determinants of Commitment to a Chosen Course of Action*, 30 HUM. REL. 431, 447 (1977). This effect may become "greater when opportunity costs for one's money . . . are presented explicitly to individuals." Simonson & Staw, *supra* note 147.

152. Simonson & Staw, *supra* note 147.

153. *Id.*

154. *Id.*

155. Staw & Ross, *supra* note 145, at 217.

156. *Id.*; see Whyte, *supra* note 140, at 313.

157. Whyte, *supra* note 140, at 313; Staw & Ross, *supra* note 145, at 217.

the project to effectuate a turnaround.¹⁵⁸ Additionally, the motivation to justify one's decisions may affect the decision-maker's search for and storage of information regarding the project's value.¹⁵⁹

In addition to self-justifying, a decision-maker also may be biased in other ways. For example, he may favor his preexisting opinion, choosing to discredit conflicting information or to make use of positive or exonerating information to the exclusion of negative or blaming information.¹⁶⁰ Additionally, the decision-maker may suffer from a self-inferential bias, becoming especially bound to a course of action when the decision to commit more resources is, *inter alia*, unambiguous, highly public, visible, irrevocable or hard to undo.¹⁶¹ Finally, the decision-maker may be biased toward choices that externally justify his previous decision, committing to a course of action because he may be insecure in his job or would like to reverse the course of a policy failure by committing more and more resources.¹⁶²

Other psychological or social factors influencing commitment to a course of action include a desire to avoid wasting resources, a norm or preference for consistency, the nature of one's opponent, audience effects, interpersonal competition, and political vulnerability.¹⁶³ Some scholars even suggest that a memory kludge explains escalation; an imprecise memory of a profit forecast may cause investors to utilize sunk costs as a signal that the prior profit forecast indicated high commitments of resources would be needed in the future.¹⁶⁴ In this event, the decision-maker may be rationalizing his actions as well as

158. Staw & Ross, *supra* note 145. Further commitment of resources somehow justifies the initial decision, or at least provides further opportunities for it to be proven correct. Northcraft & Wolf, *supra* note 145, at 226.

159. Staw & Ross, *supra* note 145, at 217.

160. *Id.*

161. *Id.*

162. Barry M. Staw, *The Escalation of Commitment to a Course of Action*, 6 ACAD. MGMT. REV. 577, 580 (1981). Staw suggests that "such *external justification* could well be stronger than the protection of self-esteem" found in internal or self-justification. *Id.* (emphasis in original).

163. *Id.* A norm for consistency predicts that organizations value administrators who are consistent in their actions over those that switch from one line of conduct to another. *Id.* at 581. Administrators are highly rated "when they followed a consistent course of action and were ultimately successful," leading to a "hero effect" for administrators who ultimately succeed after several rounds of apparent failures followed by continued commitment of resources. *Id.* For discussion of how the perception of sunk costs as potential waste encourages further investment, see Hal R. Arkes & Catherine Blumer, *The Psychology of Sunk Cost*, 35 ORGANIZATIONAL BEHAV. & HUM. DECISION PROCESSES 124 (1985).

164. Sandeep Baliga & Jeffrey C. Ely, *Mnemonics: The Sunk Cost Fallacy as a Memory Kludge*, AM. ECON. J.: MICROECON. (forthcoming) (manuscript at 3), available at <http://www.kellogg.northwestern.edu/faculty/baliga/hm/29%20Baliga%20Mnemonics.pdf> (last visited Feb. 15, 2011).

justifying his previous behavior, making escalation of commitment likely to occur.

Decisions to escalate often occur within firms where psychological and social influences are hard to prove empirically. Behavioral economics therefore may be helpful for describing escalation of commitment situations without resort to psychological and social motivation of individuals within a group.¹⁶⁵ Daniel Kahneman and Amos Tversky, pioneering scholars in the field of behavioral economics, propose one such explanation; they suggest a prospect theory positing that a decision-maker may be heavily influenced by how he frames the decision: in particular, how he perceives the risky choice in terms of gains or losses.¹⁶⁶

Generally, decision-makers, like most people, are risk averse, “normally preferring a sure thing to a gamble of equal expected value, and preferring a gamble of low variance over a riskier prospect.”¹⁶⁷ Observing research subjects making various choices between gambles of varying probability, sure losses, and sure gains, Kahneman and Tversky identified an abrupt switch to risk *seeking* when the subjects faced risky decisions; the switch could not be explained by the utility function of wealth.¹⁶⁸ They developed an alternative theory of choice under risk, which they called “prospect theory,”¹⁶⁹ proposing that the carriers of utility are gains and losses—changes in wealth, not states of wealth—“relative to some reference point, generally the status quo.”¹⁷⁰

When making risky decisions, prospect theory of choice predicts that people become risk seeking in the following four ways.¹⁷¹

165. Whyte, *supra* note 142, at 432-36 (describing the need for more broadly applicable explanations for escalation at the group level of analysis).

166. See Daniel Kahneman & Amos Tversky, *Choices, Values, and Frames*, 39 AM. PSYCHOL. 341, 343-44 (1984); Daniel Kahneman & Amos Tversky, *Prospect Theory: An Analysis of Decision under Risk*, 47 ECONOMETRICA 263 (1979) [hereinafter Kahneman and Tversky, *Prospect Theory*]. Kahneman won the 2002 Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel (often referred to as the Nobel Memorial Prize in Economics) for his collaboration with Tversky in developing the prospect theory. See Ludy T. Benjamin, *Behavioral Science and the Nobel Prize: A History*, 58 AM. PSYCHOL. 731, 739-40 (2003).

167. Daniel Kahneman & Dan Lovallo, *Timid Choices and Bold Forecasts: A Cognitive Perspective on Risk Taking*, 39 MGMT. SCI. 17, 18 (1993).

168. *Id.*

169. The prospect theory of patents and the prospect theory of decision making under risk are separate concepts. Kitch's prospect theory, or function, of the patent system refers to the prospect of future value. Kahneman and Tversky's prospect theory of decision making under risk refers to the prospect of loss driving a switch to risk seeking from risk aversion.

170. Chris Guthrie, *Prospect Theory, Risk Preference and the Law*, 97 NW. U. L. REV. 1115, 1117-18 (2003).

171. *Id.* at 1118.

First, people choosing between gains remain risk averse, but people choosing between losses become risk seekers.¹⁷² Second, people choosing between low probability gains become risk seekers, and people choosing between low probability losses remain risk averse.¹⁷³ Third, people are disproportionately loss averse—in other words, “losses loom larger than [equivalent] gains.”¹⁷⁴ Finally, people tend to “overweigh[] outcomes that are considered certain, relative to outcomes which are merely probable”—referred to as the certainty effect.¹⁷⁵ In sum, as described by Kahneman and Tversky, “a person who has not made peace with his losses is likely to accept gambles that would be unacceptable to him otherwise.”¹⁷⁶

The prospect theory of choice readily applies to commitment decisions. “[D]ecisions made subsequent to related decisions will be framed in such a way as to reflect the success or failure of the previous decision.”¹⁷⁷ In other words, a decision-maker will perceive a decision based upon positive feedback as a choice between gains, and a decision based upon negative feedback as one between losses.¹⁷⁸ Faced with such a choice between losses, decision-makers engage in risk seeking

172. *Id.* at 1118. Guthrie gives as an example the fact that people will choose to receive \$1,000 over a 50 percent chance of receiving \$2,000 (risk aversion), but will choose a 50 percent chance of paying \$2,000 over definitely paying \$1,000 (risk seeking). *Id.*

173. *Id.*

174. Kahneman & Tversky, *Prospect Theory*, *supra* note 166, at 279. As Kahneman and Tversky note, “the aggravation that one experiences in losing a sum of money appears to be greater than the pleasure associated with gaining the same amount.” *Id.* (citing Eugene Galanter & Patricia Pliner, *Cross-Modality Matching of Money Against Other Continua*, in *SENSATION AND MEASUREMENT* 65 (Howard R. Moskowitz et al., eds, 1974)). Notably, Adam Smith recognized this phenomenon 200 years earlier, in *The Theory of Moral Sentiments*: “Pain . . . is, in almost all cases, a more pungent sensation than the opposite and correspondent pleasure. The one almost always depresses us much more below the ordinary, or what may be called the natural state of our happiness, than the other ever raises us above it.” Nava Ashraf et al., *Adam Smith, Behavioral Economist*, 19 *J. ECON. PERSP.* 131, 132-33 (2005) (quoting ADAM SMITH, *THE THEORY OF MORAL SENTIMENTS* 176-77 (D. D. Raphael & A. L. Macfie eds., 1981) (1759)). Indeed, losses generally appear twice as pungent or aggravating than equivalent gains. See Kahneman & Lovallo, *supra* note 167, at 18 (describing a loss aversion coefficient from Kahneman and Tversky as 2 and from 2 to 2.5 in other cited studies); see also Richard H. Thaler et al., *The Endowment Effect, Loss Aversion, and Status Quo Bias*, in *RICHARD H. THALER, THE WINNER’S CURSE: PARADOXES AND ANOMALIES OF ECONOMIC LIFE* 63, 70 (1992) (observing a ratio of 2 to 1 between gains and losses).

175. Kahneman & Tversky, *Prospect Theory*, *supra* note 166, at 265. For example, people prefer a definite prize of a one-week tour of England over a 50 percent chance of winning a three-week tour of England, France and Italy, yet prefer a 5 percent chance at winning the three-week tour over a 10 percent chance at winning the one-week tour. *Id.* at 267.

176. *Id.* at 287. Kahneman and Tversky note that the observation that “bet[ting] on long shots increases in the course of the betting day . . . support[s] [their] hypothesis that a failure to adapt to losses or to attain an expected gain induces risk seeking.” *Id.*

177. Whyte, *supra* note 140, at 312.

178. *Id.*

instead of withdrawing from the losing endeavor, manifesting in escalated commitments.¹⁷⁹

Costs sunk into a technology research and development project may be framed as losses, turning decisions about whether to continue the original course of action into a choice between losses.¹⁸⁰ On the one hand, abandonment of the project is a certain loss. On the other hand, continuing with the highly uncertain course of action introduces a less-than-certain probability that the project will incur further losses. If the decision-maker accepts sunk costs as relevant but has not yet made peace with them,¹⁸¹ he likely will frame the choice as one between losses, and will seek risk by continuing with the course of action, for there lies a probability, however small, of success. Therefore, one consequence of framing the decision as one between losses is an escalation of commitment, which occurs regardless of whether the decision-maker suffers from cognitive biases like self-justification or other internal motivations.¹⁸² This makes prospect theory a compelling explanation for escalation of commitment behavior, especially when it occurs in projects involving research and development that are highly uncertain and involve a significant amount of sunk costs, including time, effort, and resources. If the research and development project features patented technology, the patents themselves may play a role in keeping sunk costs salient.

B. Not-So-Obvious Role of Patents as Escalators

As discussed in Part I, the patent system is often justified as providing incentives to create, disclose, and commercialize inventions—the process of innovation—which contributes benefits to society that hopefully outweigh the social harms of providing private exclusive rights to inventors for limited times.¹⁸³ Because commercialization remains a critical part of the innovation process, the question remains why some firms commercialize inventions despite a low probability of success and whether such commitments to

179. *Id.*

180. *See id.* at 316.

181. For example, if the costs still possess economic value in their original use or have yet to be fully depreciated. *See id.*

182. *See id.* As Whyte notes, some of the research in this field does not support the idea that motivational biases cause escalation. *Id.* at 314. Research subjects often pushed to complete projects despite prior extensive sunk costs, even if the subjects “were not personally responsible for the incurring of those costs.” *Id.* Moreover, subjects demonstrate escalation of commitment when participating in games of chance, even though previous failures may be credited to luck rather than individual capabilities. *Id.*

183. *See supra* Part I.

high-risk, high-reward courses of action are important to the patent system as a whole.

An important preliminary question is where do patents fit into a company's decision to invest in the commercialization of its technology? A recent survey indicates that almost all companies obtaining patent protection state that they do so in order to secure an advantage over their competition.¹⁸⁴ Since start-up companies often lack other measurable values of success, in addition to the traditional rule of excluding others, patents also play an important role among financial and reputational concerns for companies, especially in the very early stages of raising capital to fund commercialization of inventions.¹⁸⁵ Patents may also be valuable in allowing the company freedom to operate in a certain sphere, as a signal to others of technological quality or as a hedge against the failure of the company.¹⁸⁶

Based upon such survey data,¹⁸⁷ patents appear to be very important when firms make investment decisions about technology projects. Situated in the context of a long-term innovation project involving sequential investment of time, effort, and capital, patents appear to be a factor driving decisions to proceed with the project.¹⁸⁸ Indeed, the creation of innovations, obtaining patent protection, and using the resulting patents to pursue business opportunities may constitute a value chain such that the coordination of these various chain links increases returns.¹⁸⁹

Companies do not purchase patents in a vacuum, however. Research and development activities involve a number of start-up costs, including, *inter alia*, creating a new department, purchasing physical assets, hiring and training personnel, collecting information

184. Stuart J. H. Graham et al., *High Technology Entrepreneurs and the Patent System: Results of the 2008 Berkeley Patent Survey*, 24 BERKELEY TECH. L.J. 1255, 1288-89 (2009). Graham and his co-authors present data from the 2008 Berkeley Patent Survey, which collected responses about patenting decisions from 1,332 companies less than ten years old (i.e., true start-ups). *Id.* at 1260, 1272. Apart from limiting rivals (or exercising the right to exclude), firms also noted that they used patents to prevent copying by rivals, to improve their chances of securing investment from outsiders, to obtain licensing revenues from licensees, to improve the chances or quality of liquidity of their company, to defend against patent infringement litigation from others with patents, to improve negotiation positions for cross-licensing with others, and to enhance or improve the actual product's or service's image. *Id.* at 1297-1309.

185. *Id.* at 1303.

186. *Id.* at 1306-07. See generally Long, *supra* note 25 (using patents as signals); Parchomovsky & Wagner, *supra* note 30 (building patent portfolios for diversification).

187. See, e.g., Ted Sichelman, *Commercializing Patents*, 62 STAN. L. REV. 341 (2010).

188. See Marcus Reitzig & Phanish Puranam, *Value Appropriation as an Organizational Capability: The Case of IP Protection Through Patents*, 30 STRATEGIC MGMT. J. 765, 768 (2009).

189. *Id.* at 768-69.

on new technologies, and other organizational and informational activities.¹⁹⁰ Innovative companies must make an initial decision to “go/no-go” forward on research that may be at an early stage of conception.¹⁹¹ Early filing pressure of patent races and rules rush this decision forward.¹⁹² Because firms may be competing with rivals to obtain patents on early conceptions, they incur costs in reliance on future gains from obtaining patents and developing the underlying technology. Winners of this patent race obtain a patent on the early-stage technology.¹⁹³ Apart from any feelings of regret after winning the race, the patenting firm must decide whether to proceed with development of the invention.

In deciding to go ahead with inventing and to enter the patent race, a potential patent owner may have based his decisions on the net present value of future returns.¹⁹⁴ As the patent race unfolds and the patent owner devotes time, effort, and capital to the venture, he may be less likely to have an objective view of the future gains from winning the race and of the probability of success of any commercialization of the patented technology. The patent owner may therefore be poised to view the sunk costs of research and patent racing as a certain loss that must be mitigated by the hopeful gain of development of the invention. Although the remaining patent term may be shorter than he would prefer, a decision to move forward with development and the hope of gains, however remote, may be more attractive to a patent owner than abandoning the operation and leaving his hard-won patent undeveloped. By making the sunk costs of early research more salient, patent races may encourage commercialization rather than abandonment of the patented technology if patent owners frame sunk costs as losses; this in turn

190. Juan A. Máñez-Castillejo et al., *The Role of Sunk Costs in the Decision to Invest in R&D*, 57 J. INDUS. ECON. 712, 713 (2009).

191. See Pilar Carbonell-Foulquié et al., *Criteria Employed For Go/No-Go Decisions When Developing Successful Highly Innovative Products*, 33 INDUS. MARKETING MGMT. 307 (2010) (discussing go/no-go decision criteria in the context of new product development).

192. See *supra* text accompanying notes 120-137. See generally Cotropia, *Folly*, *supra* note 7.

193. And perhaps suffer from the “winner’s curse.” See Richard H. Thaler, *The Winner’s Curse*, in RICHARD H. THALER, *THE WINNER’S CURSE: PARADOXES AND ANOMALIES OF ECONOMIC LIFE* 50, 51 (1992). The “winner’s curse” describes a phenomenon where the winner of an auction will be a loser (or “cursed”) in one of two ways; either (1) the winner pays more than the good being auctioned is worth to him, or (2) the value of the good ends up being less than its pre-auction estimated value, to the winner’s dismay. *Id.*

194. See McGrath & Nerkar, *supra* note 75, at 4. According to McGrath and Nerkar, conventional investment theory “suggests firms should proceed to invest in all projects with a positive net present value” and “establish a discounted cash flow valuation for each project.” *Id.*

may drive them to commercialize inventions and invest more commitments to such technology.

Moreover, the rhetoric of incentive and reward within the patent system may encourage the sunk cost effect. Only a small percentage of patents are enforced or commercialized, yet patent filings continue to increase.¹⁹⁵ Start-up companies admit to valuing patents for their leverage to limit rivals and to raise funds more so than was previously thought.¹⁹⁶ Patents hold out the promise of future recoument.¹⁹⁷ The incentive functions of the patent system, both for invention and for commercialization, may prevent the patent owner from coming to terms with pre-patenting costs and energy invested into the technology.

Indeed, the prospect function of patents (again, not to be confused with the prospect theory of decision making) may have more of an effect in this regard. The race for a pioneering patent, or a patent broad enough to allow coordination by the patent owner of the search for improvements and commercialization, may involve “gold rush” type races. In such cases, the winner may be better invested in the technology because the prospect of the patent’s worth will be greater than in cases where the race is concerned with an unpatentable innovation or worthless market position.¹⁹⁸ In this manner, the escalation of commitment may keep the pioneering patent owner more interested in the technology, regardless of any information he may have with respect to the value of commercializing the patented technology. Despite the early patenting, the patent owner may ignore the shorter patent term and continue with investment anyway because he is too invested to quit.¹⁹⁹

Interestingly, patent race losers may also succumb to the escalation of commitment phenomenon. Because the losers have expended resources in research to win the patent race, once the winner obtains a patent, the losers will have a slate of sunk costs and fewer options for development because of the fear that they will not have freedom to operate within the space of the winner’s rights. Instead of turning to another field altogether, these firms may use knowledge gained in the race to proceed into related or similar fields with high levels of uncertainty or risk. Additionally, they may

195. Compare Allison et al., *supra* note 127 (examining litigated patents to explain where value lies in patents), with Kimberly A. Moore, *Worthless Patents*, 20 BERKELEY TECH. L.J. 1521 (2005) (quantifying patent worthlessness).

196. Graham et al., *supra* note 184, at 1326.

197. See LANDES & POSNER, *supra* note 23, at 294.

198. See Duffy, *supra* note 21, at 458.

199. See Whyte, *supra* note 140, at 313.

continue to make improvements on the original patented technology, contracting with the original patent owner over permissions and filing for blocking patents to enhance bargaining. From this vantage point, the sunk costs that companies experience in a patent race, including initial research costs, may propel the firms forward in decisions to continue with development. This will occur despite any negative feedback regarding the potential for gains within the patent term (for the patent winners) and despite any negative feedback regarding potentially limited freedom to operate (for the patent losers).

This insight may be lost if companies model research and development projects and the underlying patents as real options. As described above,²⁰⁰ the logic of real options has become very useful for companies that engage in high technology projects.²⁰¹ A discounted cash flow model—a standard model of investing in projects—requires that a company calculate the net present value of the project by discounting future estimated cash flows in accordance with the level of risk.²⁰² This model tends to dissuade investment in information, the basis of technology commercialization, because the value of information as an asset is both “intangible and uncertain,” making risk difficult to assess.²⁰³ Moreover, a discounted cash flow model also ignores the value that may be present as a result of flexibility as to how the company may accomplish the project.²⁰⁴

Companies that use a real options model make incremental decisions to invest akin to buying an option on the technology (establishing a test market, exploratory ventures or pilot programs) that “provide an opportunity for, but not the commitment to, pursuing full investments (exercising options) later.”²⁰⁵ By buying the real option on the technology, the company, in theory, can allow the uncertainty to resolve itself before further committing to the project.²⁰⁶ As with financial options, the real option retains the upside potential gains of the technology and minimizes the downside risk of loss.²⁰⁷ The option value may be far above the calculated net present value

200. See *supra* Part III.

201. See *supra* text accompanying notes 80-88.

202. Edward H. Bowman & Gary T. Moskowitz, *Real Options Analysis and Strategic Decision Making*, 12 *ORG. SCI.* 772 (2001).

203. Russell W. Coff & Kevin J. Laverty, *Real Options on Knowledge Assets: Panacea or Pandora's Box?*, *BUS. HORIZONS*, Nov.-Dec. 2001, at 73.

204. Bowman & Moskowitz, *supra* note 202, at 722.

205. Coff & Laverty, *supra* note 203.

206. *Id.*

207. See Rita Gunther McGrath, *Falling Forward: Real Options Reasoning and Entrepreneurial Failure*, 24 *ACAD. MGMT. REV.* 13, 14, 25 (1999).

that a discounted cash flow model may predict. As a result—projects that are forecasted to have a negative net present value, in other words, projects with high ex ante uncertainty for which a discounted cash flow model might recommend against investments—may have a high option value.²⁰⁸ Purchasing the option allows the company to investigate and perhaps even resolve uncertainty before fully committing its resources to the project.²⁰⁹ Critically, if and when the firm exercises the option determines whether the real option model or the discounted cash flow model better projects cost and revenues for the project. Using the real option model requires very thoughtful decisions on the part of the company with regard to exercise of the option and the resulting commitments to full or sequential investment in a technology's development.²¹⁰

Research and development to build knowledge assets, like the information protected by patents, involves both a high level of uncertainty and a specific amount of necessary technology transfer or integration with preexisting knowledge. Obviously, more uncertainty—as to future revenues and costs, as well as to technical or commercial success—drives the value of the option higher.²¹¹ A lack of integration or technology transfer upon purchase of the option, that is, a great deal of isolation of the technology from the beginning, drives the exercise price up because complementary assets and other integration within the firm may be required before the project can advance full steam ahead.²¹²

As a company approaches the decision regarding whether to exercise the option, it must take into account the uncertainty remaining as well as what the exercise price may be in terms of investment costs. If the firm has already absorbed the project, the firm may escalate its commitment to the project and exercise the option despite some remaining uncertainty; in this way, the company is seeking risk in moving forward with the project rather than accepting the previously sunk costs of purchasing the option in the first place (and any interim decisions to move forward, if this is a

208. *Id.*

209. McGrath & Nerkar, *supra* note 75, at 3. McGrath & Nerkar note that an investor who has reduced uncertainty can elect to exercise only those options that are “in the money.” *Id.*; see also Ziedonis, *supra* note 75, at 1630 (finding that firms “deciding whether to license a university technology . . . are more likely to purchase options for inventions characterized by greater technological and commercial uncertainty”).

210. Coff & Laverty, *supra* note 203, at 74.

211. In this manner, real options are similar to financial options where volatility creates a more valuable option. Kharabi, *supra* note 89, at 213.

212. Coff & Laverty, *supra* note 203, at 74.

series of options on investing in the technology).²¹³ If the project remains isolated, the firm may be more likely to decline to exercise the option, even if the technology has very promising prospects for commercialization and the firm has resolved much of the uncertainty.

By describing patents as real options, as opposed to the decisions to invest in technology projects as described above, scholars have seized upon a very useful methodology for introducing flexibility and uncertainty into the ability to value patents at the time of issuance. One drawback to the method, however, is that patents are but one piece of the innovation puzzle. Using a real options model for patenting invites the same dilemmas facing innovative companies as using a real options model generally for a smart strategy of investing in high-technology. Specifically, exercising the option may be a losing proposition that the firm is unable or unwilling to accept.

One major concern is that options on technology assume a company has the ability to delay exercising the option as the company manages uncertainty.²¹⁴ Previous models of patents as real options similarly assume that the patent option comes with a choice to delay commercialization of the underlying technology. This is true, but delay in the world of technology can have major implications. Many technological projects require maintenance. Indeed, patents require maintenance fees that companies should account for in the exercise price.²¹⁵ At minimum, maintenance fees and general technology maintenance costs may represent minioptions within the series of options represented by the patent—further decisions for the patent holder to make regarding whether to exercise the option. More problematically, however, maintenance of the patent and of the underlying technology represents further sunk costs into the project that may remain particularly salient to the patent holder.²¹⁶ Long after the sunk costs of the conception, reduction to practice, patent filing, and prosecution process, the patent holder may continue to

213. *Id.* at 75.

214. *See, e.g.,* Abramowicz, *supra* note 7, at 1076.

215. 37 C.F.R. § 1.20(e)-(j) (2011).

216. The United States adopted patent maintenance fees in 1982. *See* 35 U.S.C. § 41(b) (2006). Presently, a patent owner must renew his patent four years, eight years, and twelve years from issuance by paying an increasing fee. *Id.* If the maintenance fee is not paid within the specified amount of time, the patent expires prior to its statutory twenty-year term. *Id.* Some economists have used patent renewal information to determine patent values overall. *See* Francesca Cornelli & Mark Schankerman, *Patent Renewals and R&D Incentives*, 30 RAND J. ECON. 197 (1999); Ariel Pakes & Mark Schankerman, *The Rate of Obsolescence of Patents, Research Gestation Lags, and the Private Rate of Return to Research Resources*, in R&D, PATENTS, AND PRODUCTIVITY 73, 75 (Zvi Giliches, ed., 1984); Suzanne Scotchmer, *On the Optimality of the Patent Renewal System*, 30 RAND J. ECON. 181 (1999).

contribute small investments to the patent to keep it alive²¹⁷ and to the project overall to ensure that the technology will be ready when the final decision to commercialize will be made.²¹⁸ These losses may loom even larger than the original investment in the option and encourage patent holders to ignore continuing uncertainty in order to proceed with commercialization.

Moreover, real options logic is premised on the fact “that future investment opportunities are contingent on prior investment commitments, . . . [which] accounts for the sequential nature of choice processes” (unlike net present value models).²¹⁹ Recall that the real options model aspires to make the most of the flexibility created by a sequential investment plan that allows the options holder to abandon the project any time prior to the next investment decision.²²⁰ In order to make this opportunity a reality, the options holder must insist on creating and adhering to rigid criteria specifying how success and failure must be defined within the project.²²¹ In certain cases, an innovative company may want to make sequential investments but keep flexibility as to the possibility of discovering new research paths, even if receiving negative feedback regarding the original course of action. If the company structures its investments as real options, the company must rigidly apply its defined criteria for abandonment in order to curb downside risk, but this rigidity foregoes the fluidity of research.²²² To the extent that the patent system cares about the social benefit of innovation in its own right, then perhaps the flexibility of research and the encouragement of new paths of discovery despite negative feedback regarding the original development are more appropriate models for innovation systems.

Further, abandonment decisions by companies using real options models for their technology investments may be susceptible to the sunk cost effect and escalation of commitment. Although companies are cautioned to develop rigid criteria for abandonment so that the real options logic provides the best results and the optimal limit of downside risk, they may suffer from looming sunk costs and continue with escalation, ignoring abandonment signals and proceeding with investment or option exercise.²²³ This is a real concern, particularly in the context of high-risk, high-reward

217. See *supra* note 216.

218. See *supra* notes text accompanying notes 184-193.

219. Adner & Levinthal, *supra* note 69, at 74.

220. *Id.*

221. *Id.* at 74-75.

222. *Id.* at 75.

223. See *id.* at 74-77.

technology where the company cannot resolve uncertainty sufficiently to make the exercise decision easy at any stage of commercialization. Companies have invested enough to purchase the option and rely on the ability to abandon or delay commercialization of the technology in the event that exercising the option would be too costly or unproductive. The firm will frame as certain losses the sunk costs of initial research, the costs of patenting, and any initial investments in development that might be required to determine whether the company should move forward. Future development may seem like a long shot, but it is precisely this situation that encourages escalation.²²⁴

To be sure, because the patent system provides an incentive to expend resources—obtaining the patent and completing a certain degree of experimentation such that the standards for patentability are met—the patent itself may encourage such escalation when innovators view the patent as an asset to raise funds and to keep rivals at bay. Both of these functions serve to keep the costs of patenting, including the costs of research prior to patenting, salient in the inventor's mind. Incentivizing investment in innovation necessarily implies that private gains will outweigh private losses, which presumably include sunk costs.²²⁵ Patents thus may prevent inventors from making peace with their losses such that they may approach their future decisions with risk aversion. As a result, patents may encourage escalation of commitment to failing courses of action, or, at the very least, promote courses of action that are uncertain enough to caution against development (perhaps because the patent term is now too short for recoupment or because competitors' activities have brought the technical merits of the technology into doubt).

Escalation may occur naturally in those cases where patent owners lack the ability or desire to implement sufficiently rigid criteria to trigger abandonment when these owners receive certain negative information. This effect may be multiplied across innovative projects due to portfolio effects. Most firms obtain and enforce portfolios of patents rather than single patents.²²⁶ In such portfolios, firms are able to increase diversity and depth of technology, which in turn increases value to the firm in ways that are multiplicative rather

224. See *supra* text accompanying notes 177-182.

225. See Parchomovsky & Wagner, *supra* note 30, at 43 (noting that the portfolio approach is "the dominant approach to patenting in the real world").

226. *Id.* at 34.

than additive.²²⁷ As decisions to invest in projects rather than individual patents are made, patents may have less sway in framing decisions as between certain losses and probabilistic losses. A portfolio holder is apt to be a large firm with multiple decision-makers and perhaps more capable of abandoning projects despite large sunk costs and high levels of uncertainty regarding future success. However, patent portfolios related to an important technology project suggest one potential downside—the potential for ignoring failure signals. If technology projects comprise many patents, we can assume that the technology itself is multi-faceted, at least to the extent that the commonly owned patents are independent and distinct inventions as required by law.²²⁸ Such diverse and deep patent portfolios may suggest to the firm that it can offset failing technology segments with successful ones. In these instances, the patent portfolio may represent a rather expensive insurance policy for protecting the right to exclude others from practicing the new technology in whatever incarnation. The sunk costs from patent procurement and the lack of attention to signals of failure may combine to encourage escalation of the project at hand.²²⁹

In sum, because escalation of commitment is likely to occur in those situations where sunk costs remain on the minds of companies and their decision-makers, patent owners may be more amenable to escalate commitment to technology projects after they obtain patents on the technology. A consequence of such escalation may be overdevelopment of patented technology that might not otherwise be developed, either because technical or commercial success is too uncertain or the probability of recouping the costs of research and development are too low to continue in light of a definite patent term. If the promise of supracompetitive returns²³⁰ causes patents to keep losses looming larger, perhaps companies will abandon too few projects. Moreover, because the overdeveloped products or services may make it to the marketplace, the escalation effect may only mean

227. *Id.*

228. See 35 U.S.C. §§ 101, 121 (2006). The Patent Act defines an invention in § 101 and restricts each patent application to one “independent and distinct” invention. *Id.*

229. See Coff & Laverty, *supra* note 203, at 75. Coff and Laverty point to Minnesota Mining and Manufacturing Co. (3M), which maintains a large portfolio of patents, as an example of a firm too committed to various investments to abandon any poorly performing technologies. *Id.*

230. As described by Mark Lemley, supracompetitive returns may “not necessarily (or even often) [be] pure economic monopolies, but returns that systematically differ from the marginal cost of production.” Mark A. Lemley, *What’s Different about Intellectual Property?*, 83 TEX. L. REV. 1097, 1099 (2005) (describing such returns as “not costless” because they “distort[] the market away from the competitive norm”).

that more development occurs on such projects than would otherwise occur if the company had not obtained patents.

If companies treat patents as real options with a right to exercise by way of excluding others through leverage, litigation, and licensing, then we might believe that patents further escalate commitment to litigating patents even after the value of the patents is revealed to be lower than the potential gain from enforcement. First, the exercise of the litigation option will be easier to value than the exercise of the development option because litigation costs, while high in many cases, are at least predictable to a degree (and perhaps almost zero in the case of contingency litigation, a burgeoning method of paying for patent litigation).²³¹ Second, litigation is much easier to abandon, or to settle for less than the option value, than ongoing research and development projects with many aims and multiple goals.²³² The enforcement component of this model looks like a true real option where success can be easily defined, goals may be easily marked, and abandonment may be easily accomplished.²³³

IV. PROMOTING INNOVATION THROUGH SUCCESS AND FAILURE

Returning to Chester Carlson, our diligent patent attorney and inventor of modern office copiers, Xerox's history presents a technology development story that tests the assumptions of the sunk cost effect and escalation of commitment.²³⁴ Carlson filed his first patent application in 1937 and achieved his first technical success in 1938.²³⁵ The following two decades were spent attempting to develop the technology into a commercial office copier using xerography, first by Carlson himself, then by his successor-in-interest Batelle (who

231. See Partnoy & Martin, *supra* note 7.

232. *Id.*

233. In fact, Partnoy and Martin point to these attributes to explain why the litigation option is more favorable than the development option. See *id.* They propose making the litigation option pricier to exercise as a way of making it less attractive to patent holders as compared to the development option. *Id.* A patent "troll" may be a patent owner who solely exercises his option or series of options to litigate. *Id.*

234. Duffy, *supra* note 21, at 463-64 (describing inventions, like Carlson's, which do not involve dissipation of rents through patent races, as "situations where competition [drives] the inventor to gamble on highly risky and unpromising technologies," and rents are thus preserved).

235. OWEN, *supra* note 3, at 97-98; Oliver E. Allen, *The Power of Patents*, 41 AM. HERITAGE, Sept.-Oct. 1990, available at <http://www.americanheritage.com/content/power-patents>; *From One Copy to Trillions, Xerography Turns 70*, BUS. WIRE, (Oct. 21, 2008), <http://www.businesswire.com/news/home/20081021005141/en/Copy-Trillions-Xerography-Turns-70> (noting that the first words Carlson copied were "10-11-38 Astoria"—the date and place of his first successful attempt at xerography).

bought the patents in exchange for a large royalty on future income) and Battelle's licensee, Haloid Corporation (now Xerox).²³⁶

The interim between Xerox's original investment in Carlson's technology in 1946 and its first successful product launch in 1961²³⁷ comprised much doubt on the part of Xerox management.²³⁸ Xerox spent \$12.5 million in development of xerography before the first commercial copier, the 914 model, rolled off the assembly line in 1960.²³⁹ Consultants dismissed it, saying research showed that the machine had "no future in the office copying market."²⁴⁰ Throughout the 1950s, Xerox employees worked incessantly to perfect xerography technology and to develop a plain paper office copier despite negative feedback regarding the success of the project.²⁴¹ The Xerox 914 copier created its own market, and became a very successful technology, making its inventor, Carlson, and many others at Xerox very wealthy through stock options issued to fund the development when other revenue was insufficient.²⁴²

As Xerox engineers perfected the xerography process, Xerox applied for and obtained patents on the technology.²⁴³ Beginning with four fairly broad patents issued to Carlson, Xerox was able to obtain countless more on improvements to the original xerography technology.²⁴⁴ Xerox licensed some of these patents to competitors like IBM and Western Electric to fund development of xerography, taking the risk that one of its competitors would become interested in xerography to the extent that it would purchase a commanding share of Xerox stock.²⁴⁵ Without the original Carlson patents and the ability to immediately stop rivals from entry, Xerox may have been hesitant to invest in xerography development. With patents in hand, and a

236. OWEN, *supra* note 3, at 104-07 (recounting rejection by IBM, among others); *id.* at 117 (describing Carlson's deal with Battelle); *id.* at 127 (describing Battelle's deal with Haloid Corp.).

237. Xerox introduced a handful of copiers in the 1950s using xerography technology, but none were ultimately successful in offices. See OWEN, *supra* note 3, at 151-56. The Model A copier became successful for creating masters for certain older lithography copiers in the United States. *Id.* Revenue from the Model A and its successor models made the later 914 model possible; without it, Haloid Xerox would have had to cut back or abandon the xerography development project long before the 914 model became successful. *Id.*

238. *Id.*

239. *Id.* at 235.

240. Stephanie N. Mehta, *The Office Copier Turns 50!*, CNN (Jan. 22, 2010), http://money.cnn.com/2010/01/21/technology/xerox_copiers.fortune/index.htm.

241. OWEN, *supra* note 3, at 235.

242. *Id.*

243. *Id.*

244. *Id.*

245. *Id.*

sizable investment made to Battelle, Xerox expanded its patent protection outward and into the future with improvement patents. Not only were Xerox's managers susceptible to a great deal of psychological motivation to continue investing despite a low probability of success in the marketplace and the introduction of competing processes from rivals, but as sunk costs built up due to royalties to Carlson and Battelle and to the costs of development, Xerox's commitment began to beget more commitment.

Luckily for Xerox stockholders and employees, the gamble paid off. The gains received from the development of the 914 model, sold for many years, more than made up for the sunk costs into the project and introduced Xerox to the Fortune 500.²⁴⁶ Xerox's ability to obtain broad pioneer patents and later improvement patents enabled the company to not only view such patents as positive assets should the venture fail, but also to propel them forward to continue investing. In this way, the specter of recoupment of past losses enabled a commitment to the technology that might not have been present if Xerox did not obtain patent protection.

Xerox appears to have become a success story through persistence,²⁴⁷ but the venture could have easily failed.²⁴⁸ Often, development of patented technology despite clear negative feedback as to the probability of success may result in commercial failure.²⁴⁹ Edwin Land developed an instant movie camera in the late 1970s that had no chance of commercial success and that lost Polaroid millions.²⁵⁰ Mark Twain went bankrupt investing in the development of a patented typesetter that could not be turned into a viable commercial

246. MARIUS LEIBOLD ET AL., STRATEGIC MANAGEMENT IN THE KNOWLEDGE ECONOMY 218 (2002). Xerox became a *Fortune* 500 company in 1961. *Id.*

247. R. RAY GEHANI, MANAGEMENT OF TECHNOLOGY AND OPERATIONS 140-41 (1998) (describing Haloid's transformation into Xerox as an example of a firm that achieved high returns through maximum risk in developing a new product coupled with persistence by senior management; see also CHARLES D. ELLIS, JOE WILSON AND THE CREATION OF XEROX 216 (2006) (highlighting the persistence of Joe Wilson, President, CEO and Chairman of Haloid and then Xerox from 1946 until his death in 1971, and its effect on Haloid's growth into giant Xerox during his tenure).

248. "Time and again, potentially promising developments in xerography proved disappointing." ELLIS, *supra* note 247, at 118.

249. See *infra* note 250.

250. VICTOR K. MCELHENY, INSISTING ON THE IMPOSSIBLE: THE LIFE OF EDWIN LAND 409-24 (1998) (describing Land's insistence on commercial development of instant movie technology despite technological limitations and the advent of VHS and Betamax as superior products in the marketplace).

model.²⁵¹ Likewise, Thomas Edison almost went bankrupt developing an iron ore concentration process that was ahead of its time, yet commercially not viable.²⁵² Other failed innovations include IBM's PC Jr. and Josephson Junction computers in the early 1980s, AT&T's optical computer in the late 1980s and early 1990s, and Apple's Lisa personal computer in the early 1980s.²⁵³ Importantly, had any of these patent owners, including Xerox, objectively determined whether they could make a working model commercially and whether the pioneering or improvement patent terms provided sufficient time to recover their development costs, the companies may have abandoned the option to commercialize altogether.

There may be several explanations for continued commercialization by companies who have sunk large costs into initial patenting and early development. First-mover advantages and network effects may prove that the technology is effective even without patent protection. However, continued commercialization may also include the possibility that companies like Xerox are driven forward by patents because they keep the patent owner focused on the prospect of future gains to recoup past losses. One primary concern regarding firms' tendencies to escalate commitment to technology may be an overdevelopment of patented technology. Under this theory, patents are playing a role by incentivizing expenditures of resources on technology fraught with uncertainty. A preference for gambling in the face of certain losses comprises one driver of escalation of commitments to technology development. Certain losses are particularly distasteful to inventors and firms. As a result, a firm may choose to seek risk when deciding whether to continue with the course of action. Patents represent hope for recoupment in ways that keep losses salient and keep decision-makers framing the decision to commit more resources to development as a choice between losses rather than a choice between gains. As this Article suggests, a desire to avoid failure may drive escalation of commitments to uncertain projects bolstered by patent protection.

251. See Paul Collins, *Mark Twain's Big Mistake*, NEW SCIENTIST, Dec. 3, 2005, at 54, 54-55 (describing Twain's captivation by riches and eventual bankruptcy at the hands of a patented typesetter that failed to become a commercial success).

252. RANDALL STROSS, *THE WIZARD OF MENLO PARK: HOW THOMAS ALVA EDISON INVENTED THE MODERN WORLD 190-93* (2007). Stross notes that "Edison remained pitifully hopeful about his Ogden [New Jersey] mine, even when objective facts made the future of its business appear bleak to anyone else." *Id.* at 193.

253. See OWEN W. LINZMAYER, *APPLE CONFIDENTIAL 2.0: THE DEFINITIVE HISTORY OF THE WORLD'S MOST COLORFUL COMPANY 73-84* (2004); Duffy, *supra* note 21, at 464 n.99 (highlighting these failed innovations); Nico Krohn, *Not as Easy as 1-2-3*, INFOWORLD, Apr. 1, 1991, at 40, 41 (highlighting early personal computer failures, including IBM's PC Jr.).

The Xerox story demonstrates that society may reap great benefits from high-risk, high-reward successes achieved by those companies who escalate commitment and succeed despite negative feedback: companies like Xerox, who gamble on uncertain technologies and win big.²⁵⁴ Perhaps our patent system is better off encouraging pursuits of high-risk, high-reward inventions, and escalation of commitment may be a catalyst to such encouragement. On the other hand, a delay in development—abandonment of the technology outright—might have been better for social welfare, given the possibility of private waste and the administrative burden of granting patent rights. Moreover, what is the cost of uncertain technologies that do fail, apart from the private cost of failure? First, many failures are not total losses. For example, Edison's novel process for concentrating iron ore failed, but the technology Edison generated and protected in patents ultimately became successful after World War II.²⁵⁵ Whether due to a matter of capital or timing, one firm's failure may become another firm's success in the future.

Apart from delay or better investment strategies simply improving upon failures, technical and commercial setbacks may expand the boundaries of innovation. When companies attempt to invent technology, they develop knowledge assets, including patents, which often they can use elsewhere to develop future products or processes. Such failures breed success, and the commitments already made to gain this knowledge, as well as the right to exclude, may provide the basis for future technology gains. Patents here feed back to the innovation, encouraging further innovation by incentivizing both the patenting firm and new entrants.

Perhaps even more importantly, how can we encourage companies to learn from their failures so to create the correct level of investment without over- or underdeveloping patented technology? Although real options logic provides a useful model for sequential investments and decisions such as commercialization or litigation of patents, firms hoping to take advantage of such models must recognize the limitations. Namely, the right to abandon must be taken seriously; otherwise escalation may become a rooted problem. Some technology development problems may not lend themselves to

254. See F.M. Scherer, *The Innovation Lottery*, in EXPANDING THE BOUNDARIES OF INTELLECTUAL PROPERTY 3, 3 (Rochelle Dreyfuss et al. eds., 2001).

255. Michael Peterson, *Thomas Edison: Failure*, AM. HERITAGE INVENTION & TECH., Winter 1991, at 8.

real options logic at all, particularly if the company has the ability to affect the outcome of the investments being made.²⁵⁶

When patenting technology and employing resources, firms must recognize the tendency to escalate commitments and temper that escalation phenomenon with real options featuring rigid abandonment criteria, perhaps from an outside objective source like advisory boards. If real options theory is to be used successfully, firms must recognize that the ability to abandon the project must be a realistic option. The escalation of commitment cannot allow the firm to move past exercising time frames and thereby continue to commit to investments in technology likely to be unproductive.

V. CONCLUSION

The US patent system creates an incentive to invent and commercialize, thereby encouraging early patent races of considerable expense as well as premature patent filing. Real options logic models describe research and development projects as well as patent protection of underlying technology. Such an option includes the right, but not the obligation, to litigate, license, or leverage the patent. If patent owners make reliable decisions regarding abandonment or delay, a risk of underdeveloped patented technology may arise generally. However, because companies may prefer risk-seeking behavior when facing ambiguous or negative feedback regarding patent term or commercial viability, companies may commit to a failing course of action, “throwing good money after bad.” Modeling patents and research and development projects as a series of real options does not capture the escalating phenomenon. Such escalation may result in extraordinary success—the large reward built into high-risk, high-reward technology. Failures of technology, on the other hand, may have mixed reviews in societal welfare terms. The potential for waste may be offset by the valuable contribution to the art. By embracing and learning from both successes and failures, patent owners may achieve a better balance when making high-risk, high-reward decisions.

256. See Ron Adner & Daniel A. Levinthal, *Reply: Real Options and Real Tradeoffs*, 29 ACAD. MGMT. REV. 120, 122 (2004) (arguing that real options logic may not be appropriate “when firms can act to affect and create new outcomes—the setting of greatest interest to strategists— . . . [because firms may] overestimat[e] the potential for gains and underestimat[e] the potential for losses”).

