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Maximizing Social Welfare Through the Tailoring of Patent Duration and Using Algorithms to Calculate Optimal Patent Duration

Alvaro Cure Dominguez

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Alvaro Cure Dominguez[*]

ABSTRACT— Patents are legal devices granted by the government that confer inventors exclusive rights to their invention for a limited time. In exchange, the U.S. government requires the inventors to publicly disclose their invention to allow individuals to recreate it upon expiration of the exclusivity period. Previously, academics regarded patents as a necessary means to overcome the free-rider dilemma ("FRD"), and they assumed that, without patents, society would be deprived of many potentially valuable innovations.[1] This model has come under criticism.[2] Researchers point to cases where inventors would have innovated regardless of a patent grant.[3] They also highlight instances where patent owners use patents in ways not originally contemplated under this model and that create additional societal

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[1] The Free-Rider Dilemma describes the conundrum inventors face in a free market where, absent property rights to protect their ideas, these inventors are discouraged from innovating because free-riding competitors may copy their ideas at a fraction of the price by not incurring expensive invention costs. Maureen K. Ohlhausen, *Patent Rights in a Climate of Intellectual Property Rights Skepticism*, 30 HARV. J.L. & TECH. 103, 116–17 (2016). One "standout example is pharmaceuticals . . . [where it] is widely understood that, absent an alternative reward structure like regulatory exclusivity or suitably tailored prizes, innovation in the life sciences industry would suffer catastrophic decline without patent protection." *Id.* at 117.

[2] *See e.g.*, Lucas S. Osborn, Joshua M. Pearce & Amberlee Haselhuhn, *A Case for Weakening Patent Rights*, 89 ST. JOHN'S L. REV. 1185, 1188 (2015) (stating that "monopoly pricing and follow-on impedance represent two of the most prominent" harms that result from the patent system).

[3] *See, e.g.*, Benjamin N. Roin, *The Case for Tailoring Patent Awards Based on Time-to-Market*, 61 UCLA L. Rev. 672, 689–91 (2014) (footnote omitted) (explaining how "many inventions would reach the public even without . . . [patents because it] takes time for other firms to develop and commercialize their own version of a rival's invention, which gives the innovator time to recover some or all its R&D costs."). This is known as First-Mover Advantage. *See id.* at 738-40.

deadweight loss.[4] Furthermore, patents have a standardized term of duration, which, in many cases, is counterproductive to the patent system's intended goal of maximizing social welfare.[5]

This note explores and categorizes some of the external, noneconomic alternative mechanisms that incentivize innovation and result in inventors overcoming the FRD. This note also points to factors that affect an inventor's responsiveness to incentive mechanisms, such as industry type. The note then considers different policy levers that affect patent strength, emphasizing patent duration. The note explores how these levers interact with incentive mechanisms to create optimal duration patents that maximize social welfare. Lastly, this note proposes an algorithm for calculating optimal patent duration and identifies essential variables for feeding into the algorithm.

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I. PATENTS AS A MEANS FOR INCENTIVIZING INNOVATION

Patents have existed in the U.S. for almost as long as the nation itself. With its ratification in 1788, the Constitution granted Congress the power "[t]o promote the Progress of Science and useful Arts, by securing for limited Times to Authors and Inventors the exclusive Right to their respective

[4] *See, e.g.*, David S. Olson, *Removing the Troll from the Thicket: The Case for Enhancing Patent Maintenance Fees in Relation to the Size of a Patent Owner's Patent Portfolio*, 68 FLA. L. REV. 519, 528, 534 (2017) (discussing the deadweight loss associated with non-practicing entities and patent thickets).

[5] F.M. Scherer, *Nordhaus' Theory of Optimal Patent Life: A Geometric Reinterpretation*, 62 AM. ECON. REV. 422, 426 (1972) (describing cases where "[a] uniform policy of long-lived patent grants confers excessive private rewards in these cases" at a cost to social welfare).

Writings and Discoveries."[6] Within two years, Congress enacted the first patent statute, the Patent Act of 1790, which granted petitioners who had "invented or discovered any useful art, manufacture, engine, machine, or device, or any improvement therein not before known or used . . . [and deemed] sufficiently useful and important[, a] letters patent."[7] The letters patents (hereafter "patents") granted petitioners, "for any term not exceeding fourteen years, the sole and exclusive right and liberty of making, constructing, using and vending to others to be used, the said invention or discovery."[8] In return, the Act required the inventors to "recit[e] the allegations and suggestions of the said petition, and describ[e] the said invention or discovery, clearly, truly and fully."[9]

Conceptually, patents are a straight-forward legal instrument—an individual comes up with a new idea; the individual reduces the idea to a functional invention; the individual publicly discloses the invention with sufficient specificity so that others may reproduce; in return, the inventor receives exclusive rights from the government to use and sell their invention for a limited time.[10] From a social welfare point-of-view, society benefits from a new invention that would otherwise not have been discovered.[11] In return, society grants the inventor exclusive rights for a limited period at a cost to its social welfare.[12]

Congress adopted part of the concepts for its federal patent system from the English system.[13] In particular, the patent term of fourteen years

6 U.S. CONST. art. I, § 8, cl. 8.

7 Patent Act of 1790, ch. 7, § 1, 1 Stat. 109–12 (repealed 1793).

8 *Id*.

9 *Id*.

10 *See* Mark A. Lemley, *Ex Ante Versus Ex Post Justifications for Intellectual Property*, 71 U. CHI. L. REV. 129, 129 (2004) ("The traditional economic justification for intellectual property is well known. Ideas are public goods: they can be copied freely and used by anyone who is aware of them without depriving others of their use."); John F. Duffy, *Rethinking the Prospect Theory of Patents*, 71 U. CHI. L. REV. 439, 439 (2004); A. Samuel Oddi, *Un-Unified Economic Theories of Patents—The Not-Quite-Holy Grail*, 71 NOTRE DAME L. REV. 267, 275–77 (1996).

11 A separate but related function to invention incentives of patents is public disclosure. This is the Patent Disclosure Theory. *See* Heidi L. Williams, *How do Patents Affect Research Investments?* 5 (Nat'l Bureau Econ. Rsch., Working Paper No. 23088, 2017) (stating "[p]art of the 'grand bargain' struck by the design of the patent system is that in exchange for receiving a patent, inventors must publicly disclose their invention. This is in contrast with keeping their invention secret, which would be done – for example – with trade secrecy.").

12 *See* Scherer, *supra* note 5, at 424 (explaining the relationship between the patent term and social costs). "Ignoring the redistributive implications of this change . . . the 'price' society pays to induce a reduction in unit costs . . . is essentially the sacrifice of the 'welfare triangle' . . . from the time the invention is introduced until the date of patent expiration, plus the inventor's RD costs." *Id.*

13 Simon Lester & Huan Zhu, *Rethinking the Length of Patent Terms*, 34 AM. U. INT'L L. REV. 787, 788–92 (2019) (citations omitted); *see* Jon Dudas & David Kline, *Thank the Founding Fathers for the Open Market in Patents,* FORBES (Sept. 17, 2013, 03:07 PM),

originally stipulated by Congress was the same length as the English patent term under the Statute of Monopolies.[14] The English system, in turn, likely adopted this fourteen-year term from the standard apprenticeship term at the time in England.[15] In England, it was common for the King to confer craftsmen exclusive rights to implement their new inventions on the condition that the craftsmen take in local apprentices and train them in the technology.[16] Hence, it is also likely that, as with the fourteen-year term, the U.S. Patent system also adopted from the English system the model of granting limited-term exclusive rights—the letters patent—on the condition that inventors enable and instruct others on how to create their inventions.

A. The Patent Bargain and a Conflict of Interests

Like actors in a free market, inventors are presumably rational, profit-seeking entities looking to maximize economic returns on their invention by charging each consumer the highest price possible—the willingness-to-pay price ("WTP"). Society, representing the individual consumers' collective interest, is presumably, too, a rational, profit-seeking entity looking to pay the inventor as little as possible for their invention—the willingness-to-accept price ("WTA"). Hence, the patent strikes a bargain.[17]

In economic terms, patents represent a tradeoff—the inventor publicly discloses their invention and instructions on how to recreate it and, in exchange for this disclosure, the inventor receives exclusive rights to their invention for a limited period. The patent owner can then use these rights to create a limited-term "monopoly"[18] where the inventor fixes their invention's sale price. This price-fixing results in deadweight loss, consumer surplus, and monopoly profits.[19] *Deadweight loss* is the loss to society that results

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https://www.forbes.com/sites/forbesleadershipforum/2013/09/17/thank-the-founding-fathers-for-the-open-market-in-patents/?sh=4bf88aae220a [https://perma.cc/K5V6-QNB4] (explaining how the founding fathers, regarding the English system as skewed towards the wealthy and capital-intensive industries, intentionally "designed a patent system that could do what no other had done before, stimulate the inventive genius and entrepreneurial energy of the common man").

[14] Lester & Zhu, *supra* note 13, at 792.

[15] The standard apprenticeship term was seven years. *Id.* at 789. Although there are different theories as to why fourteen instead of seven years, most researchers agree it was due to fourteen years being a multiple of the seven-year term. *Id.*

[16] *Id.*

[17] *See* Mario Biagioli, *Weighing Intellectual Property: Can We Balance the Social Costs and Benefits of Patenting?*, 57 HIST. SCI. 140, 159–60 (2019) (representing the patent bargain as a balancing scale).

[18] As used throughout this note, monopoly refers to a patent owner's ability to fix a price for his invention above the marginal cost of production because of the patent. This is not a monopoly in the traditional economic sense because the price-fixing is still subject to certain financial limitations, such as consumers' ability to buy an alternative product. *See* Scherer, *supra* note 5, at 422–23.

[19] William Fisher, *Intellectual Property and Innovation: Theoretical, Empirical, and Historical Perspectives,* 37 INDUS. PROP., INNOVATION, & THE KNOWLEDGE-BASED ECON., BELEIDSSTUDIES

from consumers who would be willing to pay a price for the invention that is between the inventor's fixed price and the marginal cost of production ("MCP") but now, because of the patent, are outpriced and will not benefit from the invention.[20] *Consumer surplus* is the gain to society that results from consumers who would be willing to pay a price for the invention above the inventor's fixed price, but now, because of the patent, they are paying less than they otherwise would have.[21] The inventor's *monopoly profits* are the producers' gains from selling his product at a fixed price above the MCP.[22] By enabling patentees to charge and collect these monopoly profits, patents provide a means for inventors to recoup their development costs. In the case where the monopoly profits exceed development costs, the patents generate monopoly rents.[23] These monopoly profits and monopoly rents, in turn, incentivize inventors to innovate.[24]

1. The Patent Incentive Theory & The Free Rider Dilemma

With a patent, inventors receive the exclusive right to market their invention for a limited time.[25] Upon exhaustion of the patent term, this exclusive right expires, and the invention enters the public domain.[26] When the invention enters the public domain, the inventor has presumably recouped their development costs and, from this point on, market forces will determine the invention's sales price.[27] If inventors did not have the right to exclude others, competitors would be able to replicate the invention, drop the price to the MCP, and prevent inventors from recouping their development costs.

Consider, for example, the process of developing a novel, therapeutic use drug in the U.S. The process usually begins with identifying and selecting new concept compounds by chemists and biologists,; screening

TECHNOLOGIE ECONOMIE 1, 4–6 (2001), https://cyber.harvard.edu/people/tfisher/Innovation.pdf [https://perma.cc/7PX3-Q4HE] (discussing these variables and representing in graphical form); *see* Scherer, *supra* note 5, at 422–23.

20 Fisher, *supra* note 19, at 4–6.

21 *Id.*

22 *Id.*

23 Michele Boldrin & David K. Levine, *The Case Against Patents*, 27 J. ECON. PERSP. 3, 18 (2013) (explaining how, given the asymmetry between the rent of the monopolist and the individual consumer's deadweight loss, "the monopolist has an incentive to perpetuate the system while the individual consumer has no incentive to fight it").

24 Fisher, *supra* note 19, at 13 (explaining how compulsory licensing, "by reducing the profits that firms can make . . . may reduce the capacity of intellectual-property rights to stimulate innovation").

25 Eric E. Johnson, *Calibrating Patent Lifetimes*, 22 SANTA CLARA COMPUTER & HIGH TECH. L.J. 269, 272 (2006) (discussing patents as limited-term monopolies).

26 *Id.*

27 *See id.* (discussing how a patent allows patentees to "appropriate not only monetary returns from their innovations but also the psychic reward of being able to control their own creations").

these concept compounds for pharmacologic activity and toxicity; filing regulatory applications with the U.S. Food and Drug Administration; collecting efficacy and safety information in three separate phases of clinical testing; finally, if approved, marketing the new drug.[28] In 1990, researchers estimated these costs to average around $231 million dollars.[29] A group of these same researchers estimated the costs to have increased to approximately $802 million dollars in 2003.[30]

A pharmaceutical company developing a new therapeutic drug would have to account for recovery of these development costs in their product pricing model. Absent patent protection, a competitor could copy the new drug and market it at a lower price because it would not need to account for the development costs. Faced with the threat that their competitors could copy their inventions and without guarantees for recouping their investment, rational inventors would be disincentivized to innovate. This is the free-rider dilemma ("FRD").[31] Patents result in an overcoming of the FRD by allowing inventors the opportunity, through the grant of exclusionary rights and price-fixing, to recoup their costs in the form of monopoly profits.[32]

Exceptions exist and, under certain market conditions, inventors may overcome the FRD without patent incentives.[33] However, the patent system operates under the presumption that without the incentives and assurances provided by patents, inventors would be disincentivized to innovate.[34] This is the Patent Incentive Theory.[35] In markets where innovation would occur

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[28] Joseph A. DiMasi et al., *Cost of Innovation in the Pharmaceutical Industry*, 10 J. HEALTH ECON. 107, 109–11 (1991).

[29] *Id.* at 132 (using 1987 dollars).

[30] Joseph A. DiMasi et al., *The Price of Innovation: New Estimates of Drug Development Costs*, 22 J. HEALTH ECON. 151, 166 (2003) (using 2000 dollars).

[31] *See* Johnson, *supra* note 25, at 270 (comparing the free-rider dilemma to military service in a warring society).

[32] *Id.* ("Patents and copyrights are our society's flagship vehicles for overcoming the free-rider dilemma with regard to technological and artistic innovation. By granting a term of monopoly rights in the form of a patent, the government provides a mechanism for innovators to appropriate their returns from R&D expenditures").

[33] *See id.* at 276–82 (categorizing the exceptions as either "[a]narchic or [q]uasi-[l]egal [s]chemes for [a]ppropriation" or as "[b]usiness-[b]ased or [m]anagerial [a]ppropriation [s]chemes"). Two examples of these exceptions are: (1) non-profit organizations involved in finding cures for rare diseases where the social value of the cure may exceed its business value, and (2) inventors with such great personal motivation that their internal desire overcomes the invention costs—for example, the software programmer who writes an app to then give it away as open-source code for other programmers to use and improve upon. *Id.* at 276–77.

[34] *See* Roberto Mazzoleni & Richard D. Nelson, *Economic Theories About the Costs and Benefits of Patents*, *in* INTELLECTUAL PROPERTY RIGHTS AND THE RESEARCH TOOLS IN MOLECULAR BIOLOGY 17, 18–21 (1997).

[35] Stephanie Plamondon Bair, *The Psychology of Patent Protection*, 48 CONN. L. REV. 297, 314–15 (2015).

despite the grant of a patent (or with lesser exclusion rights), patents generate superfluous deadweight loss.[36] In these situations, monopoly profits are unnecessary to overcome the FRD, and they come as additional societal deadweight loss.[37] Critics of the current patent system point to this unjustified deadweight loss when calling for patent reform.[38]

Another criticism of the Patent Incentive Theory is that it does not account for deadweight loss associated with certain ancillary benefits patent owners receive, such as "blocking patents," "patent mining," "defensive patents," or "patent signaling."[39] *Blocking patents* refers to groups of patents where patentees refuse to grant licenses or accept terms that permit others to use their invention, thus effectively restricting use in a particular line of technology.[40] *Patent mining* refers to the practice of patenting inventions that create a threat comparable to "laying a minefield of patents for the unaware patentee to tread on [that] allow[s] the portfolio holder to aggressively assert [their] patent rights."[41] *Defensive patenting* refers to the practice of creating a broad, offensive patent portfolio that creates a threat of reciprocal suit and is used as a "deterrent . . . to prevent other competitors from suing."[42]

36 Scherer, *supra* note 5, at 426–27.

37 *Id.*

38 *See, e.g.*, *id.* at 427 (proposing a system with shorter-term patents).

39 *See* Kyriakos Drivas & Andreas Panagopoulos, *Using the Patent Term Changes in Assessing the Evolution of Patent Valuation From Filing to Maturity*, 19 EUR. J. INNOVATION MGMT. 528, 531–32 (2016); *see also* Boldrin & Levine, *supra* note 23, at 7–9; Florian Jell & Joachim Henkel, *Patent Portfolio Races in Concentrated Markets for Technology* 22 (Danish Rsch. Unit for Indus. Dynamics, Working Paper No. 10-23, 2010); Kimberly A. Moore, *Worthless Patents*, 20 BERKELEY TECH. L.J. 1521, 1522–23 (2005).

40 Moore, *supra* note 39, at 1522–23 n.5. The practice of blocking patents is commonly associated with "patent thickets," which refers to the practice by firms to "patent[] not just . . . the products that they actually sell, but . . . every conceivable variation of the product in order to block competition more generally." *Id.* at 1523 n.6. Blocking patent portfolios, especially in the software industry, can be asserted to hold rival competitors hostage via the control of necessary patents. Wesley M. Cohen et al., *Protecting Their Intellectual Assets: Appropriability Conditions and Why U.S. Manufacturing Firms Patent (or Not)* 25–26 (Nat'l Bureau Econ. Rsch., Working Paper No. 7552, 2000). Alternatively, patentees can also use their blocking patent portfolios to reciprocally negotiate licenses with competitors in return for access to the competitor's technologies "enabl[ing] firms to steadily improve and expand their product lines and processes" while blocking out other competitors without similar leverage. *Id.* at 26. This is known as cross-licensing.

41 Drivas & Panagopoulos, *supra* note 39, at 531–32; *see* Andrei Hagiu & David B. Yoffie, *The New Patent Intermediaries: Platforms, Defensive Aggregators, and Super-Aggregators*, 27 J. ECON. PERSP. 45, 51–53 (2013). Patent mining is a strategy usually used by non-practicing entities; that is, entities that seek to "monetize their patent[s,] not by marketing the patent's innovation, but by extracting fees from those using the patented methods when no copying occurred." Olson, *supra* note 4, at 550.

42 One researcher, Professor Olson, compares the concept of defensive patents to the theory of mutual assured destruction ("MAD") employed by the United States and Russia during the Cold War. Olson, *supra* note 4, at 526–27. Economics professors Michele Boldrin and David Levine examined a case study involving the smartphone where Apple, the market leader, and Microsoft, a player "unable to produce a product that appeals to consumers," marshaled their extensive patent portfolios against the new entrant,

Signaling refers to the practice of using patents as a proxy for a company's business acumen or as a testament to a company's research and development departments.[43]

Although these ancillary patent benefits may not directly affect the deadweight loss associated with a patent, they indirectly affect foregone consumer surplus by limiting alternative options available to consumers—that is, the consumers' ability to acquire *the next most attractive good or service*.[44] As Professor Fisher explains, "the foregone consumer surplus will consist of [the deadweight loss] minus the consumer surplus reaped by those consumers when they use their money to purchase the next most attractive good or service."[45] The negative effect of these ancillary benefits on consumer surplus is particularly conspicuous in blocking patents.[46] A second criticism of the Patent Incentive Theory is that it fails to account for noneconomic incentives that inventors may have for innovation.[47]

2. *The Behavioral Economic Theory*

Researchers have found that "individuals, in general, undertake creative activities not for a monetary reward, but because they are intrinsically motivated to do so—because they wish to 'engag[e] in [the] activity for its own sake, out of interest, or for the pleasure and satisfaction derived from the experience.'"[48] This is part of the Behavioral Economic Theory. The Patent Incentive Theory's utilitarian-focused framework fails to account for psychological and other behavioral traits that affect an inventor's decision to

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Google, who, while wealthy, lacked a similarly large defensive portfolio to countersue. Boldrin & Levine, *supra* note 23, at 8–9. The researchers point to how these patent litigations have "generat[ed] hundreds of millions in wasteful legal costs and no social benefit whatsoever." *Id.* at 8.

[43] *See generally* Clarissa Long, *Patent Signals*, 69 U. CHI. L. REV. 625, 627–28 (2002). Professor Long points to the "particularly valuable signaling role" that patents have in start-ups where venture capitalists use patents as a proxy for good management. *Id.* at 653.

[44] Fisher, *supra* note 19, at 5 n.9.

[45] *Id.*

[46] Because patentees aim their blocking patents at preventing rivals from patenting or using related inventions, these patents create a "patent fence" around a core invention that forecloses the possibility to rivals to develop substitutes, regardless of whether the substitutes "represent improvements upon the original product or not [or whether] the firm [has the] intent of commercializing those inventions." Cohen et al., *supra* note 40, at 22. For example, the authors point to a case where du Pont "patented over 200 substitutes for Nylon to protect its core invention." *Id.*

[47] Bair, *supra* note 35, at 314 (commenting how "[a] number of intellectual property scholars have pointed to a key finding from the psychology literature that calls the basic premise [that a patent is needed to overcome the free-rider problem and encourage potential inventors to engage in innovative activities] into question.").

[48] *Id.* at 314–15 (quoting Hsiu-Fen Lin, *Effects of Extrinsic and Intrinsic Motivation on Employee Knowledge Sharing Intentions*, 33 J. INFO. SCI. 135, 137 (2007)).

innovate and which may result in the overcoming of the FRD despite an untethering of innovation and financial retribution.[49]

Under the Behavioral Economic Theory, "individuals do not always behave in strict accordance with the predictions of rational actor theory [and] some 'irrationalities' . . . or pervasive deviations from welfare maximization [are common]."[50] Inventors find sufficient compensation from noneconomic rewards, such as social recognition or personal satisfaction, which, in turn, compensate and offset the inventor's development costs.[51] One researcher, Professor Stephanie Bair, identified relevant intrinsic motivators: attribution, prestige, competition, and, in the case of employees working within an organization, personal recompense.[52] One caveat to Professor Bair's model is that it presumes inventors are individuals whereas, in practice, most inventors obtaining patents are inventors within institutions, who "may be more likely to behave like rational actors, undertaking cost-benefit analyses and subject to utilitarian incentives."[53]

This caveat is relevant because, in the U.S., most patent holders are institutional entities.[54] One researcher, Professor Dan Burk, reconciled the Behavioral Economic Theory with institutional patent holders' pervasiveness by analyzing patenting behavior under a new institutionalism framework.[55] The *new institutionalism framework* "views both rationality and efficiency as socially constructed concepts."[56] Under the new institutionalism framework, inventors "act[] rationally, not necessarily . . . [by] advancing their material well-being, but in the sense of defining and expressing their identities in socially appropriate ways."[57] Hence, under a new institutionalism analysis, rational behavior includes not only profit-maximizing behavior but also behavior that has become "institutionalized"—that is, the behavior that has an "acceptable legitimizing explanation" under social norms, even if it is not profit-maximizing.[58] An

49 *Id.* at 314–17.

50 Dan. L Burk, *On the Sociology of Patenting*, 101 MINN. L. REV. 421, 426 (2016) (citing Christine Jolls et al., *A Behavioral Approach to Law and Economics*, 50 STAN. L. REV. 1471, 1477–78 (1998)).

51 Bair, *supra* note 35, at 314–15.

52 *See id.* at 314–77.

53 *Id.* at 318.

54 Between 1976–78, more than 75% of all patent rights were assigned to corporate entities. John R. Allison & Mark A. Lemley, *The Growing Complexity of the United States Patent System*, 82 B.U.L. REV. 77, 97 (2002).

55 Burk, *supra* note 50, at 427–30; *see also* Mark C. Suchman & Lauren B. Edelman, *Legal Rational Myths: The New Institutionalism and the Law and Society Tradition*, 21 L. & SOC. INQUIRY 903, 911–13 (1996).

56 *See* Burk, *supra* note 50, at 439.

57 *Id.*

58 *Id.* (comparing institutional behavior to a "self-fulfilling prophec[y]").

institution's research and development efforts—and by extension, its patenting initiatives—are then self-serving measures for institutions wishing to "align themselves with dominant social myths."[59] This is similar to signaling, but is noneconomic in nature.[60]

An example of economically irrational patenting behavior that may be better understood under the new institutionalism framework is university patenting.[61] Universities spend significant resources accumulating patents.[62] However, these patents rarely generate any appreciable income to offset their research and development costs.[63] Professor Burk explains that this seemingly irrational behavior is a result of the university's loose coupling of their granted patents and the value the university receives from "justify[ing] their activities to alumni and to philanthropic donors . . . demonstrat[ing] that the university is 'giving back' to the community [and] stimulating local business and economic growth by moving the fruits of research into the commercial sector."[64] In other words, patents provide to the university a means for social legitimization and a way to represent itself as a "technologically progressive and innovative [institution], worthy of the trust that investment or employment entails."[65]

Under the new institutionalism framework, incentive measures to promote innovation should consider not only economic incentives but also the prevalence of "inventor myths" within an industry and the effect of these narratives on an inventor's desire to conform.[66] The primacy of these

[59] *Id.* at 433–37 (arguing that "in many cases [having a research and development program] is not a calculated decision [but] simply accepted as the way things are properly done.").

[60] *Id.* at 440–42 ("[A]cquisition of patents sends a type of signal to competitors, employees, and investors . . . not a signal of economic efficiency. Rather, the signal in question here is a social or ceremonial signal, not an economic one. The signal is one of compliance and reputability, an indication of *participation in the expected social order*.").

[61] *Id.* at 444–46.

[62] *See* Lorelei Ritchie de Larena, *The Price of Progress: Are Universities Adding to the Cost*, 43 HOUS. L. REV. 1373, 1374–76 (2007) (noting how The Bayh-Dole Act has "turned universities into commercial entities . . . [and] allowed universities to irresponsibly over-patent").

[63] *See, e.g.*, WALTER D. VALDIVIA, UNIVERSITY START-UPS: CRITICAL FOR IMPROVING TECHNOLOGY TRANSFER 6-10 (2013) (concluding that "only [a] few universities raise significant revenue from their patents and most universities lose money in their technology transfer operations"); Brian J. Love, *Do University Patents Pay Off - Evidence From a Survey of University Inventors in Computer Science and Electrical Engineering*, 16 YALE J.L. & TECH. 285, 329 (2014) (concluding from survey data that "universities and faculty members alike generally lose more than they gain from filing patents on high-tech research").

[64] Burk, *supra* note 50, at 445.

[65] *Id.* at 442.

[66] *Id.* at 440–42. Inventor myths are "th[ose] myth[s] of the solitary genius who is motivated and rewarded for his efforts." *Id.* at 441.

inventor myths may be more influential in driving intellectual property allocations than as "contemplated under the myth of incentive to innovate."[67]

Failure to account for these two noneconomic, behavioral factors—social legitimization and inventor myths—may result in additional deadweight loss to society by granting unduly broad patents in situations where inventors would have been incentivized to pursue their invention with lesser rights.[68]

B. Mechanisms for Incentivizing Innovation

Patents and intrinsic motivation are not the only two ways inventors overcome the FRD under the Patent Incentive Theory. A helpful way to organize the various ways that inventors overcome the FRD is to categorize them as Legal Mechanisms ("LMs"), Quasi-Legal Mechanisms ("QLMs"), and Business-Based Mechanisms ("BBMs"). *LMs* are mechanisms that use "coercive power to create and enforce rights and redistribute resources."[69] LMs include monopoly rights (such as patents), government rewards, government subsidies, and trade secret protection.[70] *QLMs* are extralegal mechanisms that depend on goodwill and a sense of moral duty.[71] QLMs include internal motivation, community-based initiatives, and non-profit associations.[72] QLMs work best in relatively small groups with common interests[73]—for example, a non-profit foundation funding research for a rare disease where the medicine's social value may exceed its development costs. There is skepticism about the effectiveness of QLMs in larger groups with diverse interests or in resource-intensive innovation efforts, such as industries with high regulatory or research expenses.[74]

BBMs are mechanisms that "take advantage of market conditions and the decision-making characteristics of customers" so that inventors may profit from their innovation without other governmental or quasi-legal incentives or protections.[75] BBMs include first-mover advantages, sales and service efforts, quickness, manufacturing capacity, increasing returns, and

67 *Id.* at 441–42.

68 *Id.* at 450 (commenting how the new institutional theory "allow[s] for a conversation about . . . patent law even though [it] reject[s], or at least circumnavigate[s], the economic incentive paradigm for patents").

69 Johnson, *supra* note 25, at 271–72.

70 *Id.* at 272–76.

71 *Id.* at 276.

72 *Id.*

73 *Id.*

74 *Id.* at 281–82.

75 *Id.* at 271–72, 277–78.

the establishment of proprietary architecture.[76] Unlike LMs and QLMs, BBMs are "morally neutral."[77] In other words, while LMs typically seek to further social welfare and QLMs arise from community-based values, BBMs do not have a similar moral grounding. BBMs are "byproducts of market realities [that] . . . extract[] profit from innovation."[78] For this reason, BBMs can result in outcomes that have negative social-welfare effects and for which LMs may be a suitable response to subvert these negative outcomes.[79]

These incentive mechanisms do not operate exclusively from one other. When researchers or legislators consider means for incentivizing innovation, it is essential they consider how the incentives within the different categories interact. For example, when granting a patent, which is an economic incentive, the government should consider whether the inventor has any other independent economic incentives to pursue the invention, such as signaling to investors, or noneconomic incentives, such as personal gratification. Granting a patent in situations where economic incentives are unnecessary results in deadweight loss to society since the inventor would have likely innovated without the patent or with a patent with lesser exclusionary rights.[80]

II. PATENT LEVERS AFFECTING PATENT STRENGTH AND MODELS FOR PATENT LEVER MANIPULATION

Despite the general criticisms of the patent system[81] and the noted shortcomings of using a standardized, fixed-duration patent term to

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76 *Id.* at 278–81; *see also* Dan L. Burk & Mark A. Lemley, *Policy Levers in Patent Law*, 89 VA. L. REV. 1575, 1584–89 (2003).

77 Johnson, *supra* note 25, at 277.

78 *Id.* at 277–78, n.24.

79 *Id.* at 277–78. The potentially socially harmful distinctions between LMs and BBMs arise in their goals. While LMs "aspire to make society better off or to uphold some other philosophical value," BBMs do not have such lofty aspirations, but have the sole objective of maximizing profits for the equity holder. *Id.* at 271–72. An example of a socially detrimental BBM is the establishment of a proprietary architecture, such as a social platform, where the inventor can extract profits that overcome the FRD, but where the inventions are focused on maximizing economic appropriations for the original inventor and not for the benefit of society at large. On the other hand, patents are intended to stimulate innovation that will be beneficial to society at large.

80 Professor Frank Partnoy considers this issue in finance-related business method patents, where he argues that inventors would have developed these methods regardless of whether they received a patent. Frank Partnoy, *Finance and Patent Length* 15–16 (U. San Diego, Law and Econ. Research Paper No. 19, 2001) ("Inman's case (and others like it) raise some difficult questions about how such claims should be treated. On one hand, patent law historically has been inapplicable to these types of patents, primarily because of the view that society did not need to incur the costs (deadweight and distributional) associated with the grant of patent rights in order to encourage this kind of innovation. Why should an inventor receive seventeen, or now twenty, years of protection for innovation that likely would occur anyway?").

81 *See, e.g.*, Ann Bartow, *Separating Marketing Innovation from Actual Invention: A Proposal for a New, Improved, Lighter, and Better-Tasting Form of Patent Protection*, 4 J. SMALL & EMERGING BUS.

incentivize innovation,[82] the United States Patent and Trademark Office ("USPTO") continues to grant patents based on a fixed twenty-year term.[83] While some authors are incredulous as to whether patents can accomplish their intended goal of incentivizing innovation,[84] other authors are more optimistic and point to how patents are but one tool in a shed.[85] As a tool, patents may be "sharpened" to better reflect their intended goal of promoting social welfare. To sharpen them to accomplish this goal of advancing social welfare, it is essential that legislators consider the different patent protection dimensions.

Envision a patent as a fence and the enclosed area as the invention. The fence's protection is determined by the length, height, material, and duration of time that the fence is up. The fence's actual boundaries—the "scope" of the invention—are defined by the patent's claims and how courts will interpret these claims.[86] The court's interpretation of the patent's claims, or "delineation," is known as claim construction and is beyond this note's scope. For purposes of this note, suffice it to note that a patent's scope is decidedly more uncertain than its duration, which Congress has generally fixed at twenty years.[87] The dimensions that constitute a patent's exclusionary rights are "levers."[88] Just as a fence's effectiveness can be altered by strengthening its materials or increasing its height, the government can reduce or expand a patent's exclusionary rights by manipulating these levers.

Two commonly discussed levers for tailoring patents are duration and scope.[89] Examples of other levers include enforcement rights, antitrust regulations, compulsory licensing, geographic coverage, economic conditions, and business and management conditions.[90] The interplay between these levers ultimately determines a patent's exclusionary rights.

L. 1, 11 n.56 (2000) (citing how there "[is] no unified economic theory of patents that adequately describes the overall patent system, demonstrates that the patent system provides a net societal benefit, or consistently predicts the outcome of individual patent disputes").

82 Scherer, *supra* note 5, at 426–27.

83 35 U.S.C. § 154(a)(2).

84 Mark A. Lemley, *Faith-Based Intellectual Property*, 62 UCLA L. REV. 1328, 1336–37 (2015).

85 Johnson, *supra* note 25, at 271–81.

86 Robert P. Merges & Richard R. Nelson, *On the Complex Economics of Patent Scope*, 90 COLUM. L. REV. 839, 839–44 (1990).

87 Johnson, *supra* note 25, at 286 ("The breadth or scope of a patent is doctrinally much more complicated than duration. A change in scope can [modify] the kinds of inventions that can be patented").

88 *See* Burk & Lemley, *supra* note 76, at 1579–80 (describing patent levers as flexible legal standards that allow courts the responsibility to adapt patent statutes to evolving technologies and "implicitly or explicitly permit the courts to take account of different types of innovation in different industries").

89 *See* Johnson, *supra* note 25, at 285.

90 *See id.* at 285–89.

One researcher, Professor Mario Biagioli, notes how there is substantial tension between a patent as a fixed legal object when it is first granted, a "baby patent," and the different embodiments the patent will assume over its twenty-year life as it navigates through the legal system.[91] For incentivizing innovation, LMs generally have an advantage over QLMs and BBMs in that they are under direct government control and are coercively enforced by the government.[92] In the case of patents, this control confers the government the power to tailor a patent's exclusionary rights via manipulation of policy levers.[93] Patent duration is an ideal lever for manipulation because it is a fixed lever and the government can distinctly manipulate it across different industry types.[94] By adjusting patent duration, the government can tailor patents to produce welfare-maximizing outcomes—that is, optimal patent lengths.[95] Patents with optimal lengths (or optimal duration) will bestow inventors with sufficient monopoly profits to entice them to innovate without incurring surplus societal deadweight loss.[96]

A. Patent Duration as a Lever for Tailoring Patent Rights

Congress has a history of manipulating patent duration to further innovation policy.[97] For example, in the nineteenth century, either Congress or the Commissioner of Patents would periodically extend individual patent terms from fourteen to twenty-one years upon showing by a patentee that they had not "obtained sufficient remuneration during the original patent term."[98] In response to requests for a longer, twenty-year patent term, Congress modified the patent term from fourteen to seventeen years *from the*

[91] Biagioli, *supra* note 17, at 154 (specifically referring to the different embodiments patents may assume as "enabled by the doctrine of equivalents").

[92] *See* Johnson, *supra* note 25, at 272–81. QLMs, on the other hand, depend on a community's goodwill and sense of moral duty, so they are not subject to government controls. *Id.* at 271. Likewise, BBMs depend on market conditions and customer preferences, so they are not subject to government controls. *Id.*

[93] *See id.* at 272.

[94] *See id.* at 288-89.

[95] *See* Scherer, *supra* note 5, at 424.

[96] This optimal duration is an equilibrium based on the inventor's development costs and their ability to appropriate returns during a patent term to offset these costs. *See id.* at 424 (explaining how the more extended a patent term is, the better a profit-maximizing firm can appropriate returns, but at a price to society welfare).

[97] Mark A. Lemley, *An Empirical Study of the Twenty-Year Patent Term*, 22 AIPLA Q.J. 369, 374 n.19 (1994).

[98] *Id.* (citing David S. Forman & Thomas W. Winland, *How Will Existing License Agreements be Affected by Extended Patent Terms Under GATT*, 22 AIPLA Q.J. 449 (1994)).

issue date[99]—issue date referring to the date when the USPTO issued the patent after determining the applicant was "entitled to a patent under the law" and the applicant had paid the issue and publication fees.[100] In 1994, with the enactment of the General Agreement on Tariffs and Trade ("GATT"), Congress modified the patent term to twenty years from *the filing date*[101]—filing date referring to "the date on which a specification, with or without claims, was received in the United States Patent and Trademark Office."[102]

Aside from these comprehensive congressional patent duration reforms, administrative agencies have also modified patent duration via focalized exceptions.[103] One such exception is found in the Drug Price Competition and Patent Term Restoration Act of 1984 ("Hatch-Waxman Act"), which seeks "to extend the life of drug patents and patents of other regulated products."[104] The Hatch-Waxman Act improves one known shortcoming of patents in the pharmaceutical industry—given the extraordinary development costs and exceptional risks of failure in the industry, patent durations may be too short to incentivize innovation.[105] The Hatch-Waxman Act provides for an extension of patent terms under certain conditions.[106]

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99 *See* Victor Abramson, *The Economic Bases of Patent Reform*, 13 L. & CONTEMP. PROBS. 339, 348 (1948) (criticizing the fixed-term patent grants); Lemley, *supra* note 97, at 372 (citing 35 U.S.C. §§ 155, 156 (1988)).

100 35 U.S.C. §§ 151–54.

101 35 U.S.C. § 154. Congress implemented this adjustment in 1994 as part of the U.S.'s obligations under the TRIPS Agreement by enacting the Uruguay Round Agreements Act. Uruguay Round Agreements Act, Pub. L. No. 103-465, 108 Stat. 4809 (1994). Although Congress did not implement this adjustment to incentivize innovation, at least one researcher studied the effects of the change of patent duration on innovation. *See* David S. Abrams, *Did TRIPS Spur Innovation? An Analysis of Patent Duration and Incentives to Innovate*, 157 U. PA. L. REV. 1613, 1641–42 (2009) (finding that the change in patent duration "had a heterogeneous impact across patent classes").

102 35 U.S.C. § 111(a)(4).

103 *See* 35 U.S.C. §§ 155–56 (empowering the U.S. Food and Drug Administration (FDA) to extend process and composition of matter patents to compensate for delays in regulatory approval).

104 *See* U.S. PAT. & TRADEMARK OFFICE, U.S. DEP'T OF COM., MANUAL OF PATENT EXAMINING PROCEDURE § 2750 (9th ed. 2020) (stating how one part of the Hatch-Waxman Act "was designed to create new incentives for research and development of certain products subject to premarket government approval by a regulatory agency"); Joanna Thompson, The Case for Extending Patent Terms for Drugs That Treat Rare Diseases 14–19 (June 2013) (M.A. thesis, University of Denver) (ProQuest); *see also* Henry Grabowski & John Vernon, *Longer Patents for Lower Imitation Barriers: The 1984 Drug Act*, 76 AM. ECON. REV. 195, 197 (1986) (estimating that the Hatch–Waxman Act added about three years to the effective life of pharmaceutical patents).

105 While Title I of the Hatch-Waxman Act focused on generic drugs, Title II sought to extend the life of drug patents to "help[] . . . compensate for regulatory delay and ensure that innovators had 'a reasonable opportunity to recoup development costs and to make a profit irrespective of the existence of patents.'" Thompson, *supra* note 104, at 16 (citing Alfred B. Engelberg, *Special Patent Provisions for Pharmaceuticals: Have They Outlived Their Usefulness - A Political Legislative and Legal History of U.S. Law and Observations for the Future*, 39 IDEA 389, 406 (1999)).

106 *Id.*

However, because this adjustment is a fixed-term *ad hoc* correction, uncorrelated to economic or behavioral variables that affect an inventor's incentives to innovate, the Hatch-Waxman Act has not resolved the issue of granting patent terms that are social welfare-maximizing.[107] Effective modifications to patent duration should consider industry-specific preferences and account for differences in responses to economic and noneconomic incentives.

B. Lever Manipulations Should Account for Industry Differences

Patents do not incentivize innovation equally across industries.[108] Researchers have found abundant empirical evidence to support this.[109] Drivas and Panagopoulos found that the pharmaceutical and chemical industry valued patents more than any other sector.[110] Corroborating their finding, Professor Edwin Mansfield discovered that, while patents were unnecessary in several industries to incentivize innovation, the pharmaceutical industry would not have introduced into the market most—(65%)—of its inventions without a patent incentive.[111] One researcher, Judd N.L. Cramer, argued that, while patents appeared to be significant in the Drugs & Medical, Computers & Communication, and Chemicals and Electrical categories, patents were "particularly important for inventions in the Drugs & Medical category."[112] In fact, patents are so critical in the pharmaceutical industry that, in instances where pharmaceutical companies cannot secure patent protection due to novelty or nonobviousness issues, companies likely forego the development of a new drug and deprive society of potentially valuable innovations.[113]

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107 *See* 35 U.S.C. § 156 (describing the conditions for granting extensions).

108 Dan L. Burk, *Law and Economics of Intellectual Property: In Search of First Principles*, 8 ANN. REV. LAW SOC. SCI. 397, 410–11 (2012) (noting that "the costs of innovation in different technologies vary significantly and that the industrial sectors that rely on these technologies experience the patent system differently . . . [and] where development costs are astronomical and where the risks of lost investment are high, . . . a greater reward to prompt investment [is required]").

109 *See, e.g.*, Allison & Lemley, *supra* note 54, at 139–44; 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, 1274–1320 (2009).

110 Drivas & Panagopoulos, *supra* note 39, at 529–30 ("This result . . . finds patents as being more valuable (as incentives to innovate) to the pharmaceutical and chemical industry. . . ."); Judd N. L. Cramer, Essays in Labor Economics and Innovation 31 (Jan. 2019) (Ph.D. dissertation, Princeton University).

111 Edwin Mansfield, *Patents and Innovation: An Empirical Study*, 32 MGMT. SCI. 173, 175 (1986); *see also* Richard C. Levin et al., *Appropriating the Returns from Industrial Research and Development*, 3 BROOKINGS PAPERS ON ECON. ACTIVITY 783, 797, 816 (1987).

112 Cramer, *supra* note 110, at 32–33.

113 Benjamin N. Roin, *Unpatentable Drugs and the Standards of Patentability*, 87 TEX. L. REV. 503, 515–16 (2009) (arguing for the implementation of an FDA-reviewed exclusivity period for drugs that

However, the pharmaceutical industry is atypical. Compared to other sectors, this industry has exceptionally high development costs combined with an extremely low likelihood of success.[114] To illustrate, the probability of a compound in preclinical development resulting in a marketable product is less than 1 in 4,000.[115] Of the products that make it to the market, only three in ten will produce enough revenue to recoup research and development ("R&D") costs.[116] Pharmaceutical companies rely on the "one blockbuster drug" to offset the R&D and marketing costs for all of their unviable research attempts and commercially unfruitful products.[117] Without exclusionary patent rights for this one blockbuster drug, competitors could freeride off the inventor's costly R&D and sell the product at the MCP. Given the exceptionally high stakes, it is unsurprising that the pharmaceutical industry also has higher patent litigation rates than other industries.[118]

In stark contrast, the Tech[119] industry is so disaffected by patents and patent incentives that, at one point, they openly lobbied Congress for shortened patent terms[120] and reported that they would have developed most of their inventions without having patent incentives.[121] To remedy what they viewed as a "deeply dysfunctional" patent system, the Tech industry pushed for a patent reform bill—the Leahy-Smith America Invents Act of 2011

complete the FDA's clinical-trial process to promote the development of unpatentable drugs); *see also* Rachel E. Sachs, *Prizing Insurance: Prescription Drug Insurance as Innovation Incentive*, 30 HARV. J.L. & TECH. 153, 164 (2016) (suggesting pharmaceutical companies show bias to developing drugs with "comparatively short[er] development times" because of the fixed patent duration).

114 Roin, *supra* note 113, at 507–15.

115 Michael A. Carrier, *Two Puzzles Resolved: Of the Schumpeter-Arrow Stalemate and Pharmaceutical Innovation Markets*, 93 IOWA L. REV. 393, 417 (2008).

116 Thompson, *supra* note 104, at 28.

117 *Id*.

118 Moore, *supra* note 39, at 1547–48; Allison & Lemley, *supra* note 54, at 140 ("In particular, patent litigation is especially likely to occur in the biotechnology and pharmaceutical industries, the two industries whose patentees spent the most time in prosecution and that were the second and third highest citers of prior art").

119 As used colloquially and in this note, "Tech" refers to "business[es] that provide a digital technical service/product/platform/hardware, or heavily rel[y] on it, as its primary revenue source," and includes software, semiconductors, and hardware companies. Catherine Heath, *What is a 'Tech Company,' Anyway?*, TECH NATION (Nov. 1, 2017), https://technation.io/news/tech-company-definition/ [https://perma.cc/H26U-XQ5E].

120 *See* Matt Richtel, *Chairman of Amazon Urges Reduction of Patent Terms*, N.Y. TIMES (Mar. 11, 2000), https://www.nytimes.com/2000/03/11/business/chairman-of-amazon-urges-reduction-of-patent-terms.html [https://perma.cc/5AQT-93MJ] (reporting how the chairman of Amazon was "calling for the government to limit patents for software and Internet business models to three to five years and to require a period for public comment on patent applications in those areas before they [we]re granted").

121 Roin, *supra* note 3, at 678–81.

("AIA").[122] Given their divergent views on patents, the AIA pitted the pharmaceutical and Tech industries (and their lobbying muscles) against one another. The result was a stalemate. The bill eventually passed, but without any of its original ideals.[123] Research and development costs partly explain the stark difference between the pharmaceutical and Tech industries.[124] Industries with high development and regulatory costs will favor patents and exclusionary rights, whereas industries with low development and regulatory costs will be less favorable to patents.[125] This observation could explain why, within the Tech industry, subindustries with higher development costs (*e.g.*, hardware and semiconductors) display mixed-effects regarding patents while subindustries with lower development costs (*e.g.*, software) display negative patent effects.[126] Another author, Professor Carl Shapiro, noted how, in fast-moving industries, the rules governing patent litigation and settlements might be "arguably far more important to patentees" than patent duration.[127] Thus, lever manipulations seeking to modify patent rights based on patent duration should account for these differences in development costs amongst industries.

Development costs, however, are not the only factor that should be accounted for when adjusting patent duration to tailor patent rights. As suggested under the new institutionalism framework, noneconomic factors also have a role.[128] Two such factors are the pervasiveness of inventor myths within an industry and the role of social legitimization as a signal.[129] This is likely the case in institutionalized behavior, such as in universities, where a patent's prestige may carry more value than its potential economic returns.[130]

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[122] *Id.* at 679.

[123] *See id.* at 704–12.

[124] *See id.* at 680.

[125] *Id.*

[126] *See id.* at 717-81*;* One other distinction with Tech patents is that inventors often direct them at unpatentable "abstract ideas." *See* Tanner Mort, *Abstract Ideas: The Time Has Come for Congress to Address the Patentability of Software and Business Method Inventions*, 56 IDAHO L. REV. 383, 386 (2020) (citing Alice Corp. v. CLS Bank Int'l, 573 U.S. 208, 219–20 (2014)) (explaining how "inventors claiming entitlement to a patent for a software or business method innovation may commonly be denied such a grant, as the only thing the inventor may have accomplished is to implement a well-known practice that is 'long prevalent in our system of commerce' on a Computer").

[127] Carl Shapiro, *Antitrust Limits to Patent Settlements*, 34 RAND J. ECON. 391, 392 (2003).

[128] *See* Burk, *supra* note 50, at 440–42.

[129] *See id*.

[130] *See id.* at 440–45. The other often mentioned setting where inventors highly prize patents for their signaling value is in startups. *See* Graham et al., *supra* note 109, at 1306–08 (detailing four theories of why patents are essential in attracting venture capital to startup firms); *see also* Long, *supra* note 43, at 642 (explaining how rational actors may still seek patent protection "when a patent's expected signaling value is high, even if the expected but-for rents are negligible or the expected costs large"). Given this

Given these differing values and views on patents amongst industries, it is unsurprising that individual inventors within different industries will respond differently to lever manipulations.

C. Models for Manipulating Patent Duration to Affect Patent Strength

There are various ways in which governments may manipulate patent duration to incentivize innovation and adjust for industry-specific economic and noneconomic behavioral factors.[131] One scholar, Professor Eric Johnson, separated these manipulation mechanisms as either *ad hoc*—that is, adjustments relative to a fixed value—or comprehensive—that is, systems that prescribe a patent duration value.[132] Examples of *ad hoc* fixes include modifying duration based on market reach (*e.g.*, inventions with a global market would have shorter durations) or tailoring patent terms to macroeconomic conditions (*e.g.*, extending patent durations during economic downturns).[133]

On the other hand, comprehensive systems focus on prescribing absolute patent duration values rather than adjustments to pre-fixed values.[134] These values are determined by economic models based on empirically-backed data from various categories and help calculate a patent's "optimal patent life."[135] Professor Johnson provided five examples of comprehensive models: 1) legislative processes where Congress balances industry interests to find a patent duration that satisfactorily balances all interests among inventors; 2) durations set by administrative agencies that balance industry and societal interests; 3) an *ad hoc* framework system to allow negotiation of patent durations between affected actors; 4) a system of standardized, fixed, and industry-specific patent durations where inventors have the option to apply for extended patent durations in an adversarial hearing with government counsel; and 5) a system of automatic or semi-automatic algorithms that combine an inventor's financial information with other

trend, I expect that in industries with a high concentration of startups or in relatively new industries, the value attributed to patents for their signaling capability would be higher than in older industries.

131 *See, e.g.*, Richard Gilbert & Carl Shapiro, *Optimal Patent Length and Breadth*, 21 RAND J. ECON. 106, 108–11 (1990) (analyzing the relationship dynamics between patent duration and patent "breadth"); *see also, e.g.*, Paul Klemperer, *How Broad Should the Scope of Patent Protection Be?*, 21 RAND J. ECON. 113, 113 (1990) ("For example, if a company invents a new drug to alleviate a heart condition, how similar a drug should a competitor be allowed to sell?"); Louis Kaplow, *The Patent-Antitrust Intersection: A Reappraisal*, 97 HARV. L. REV. 1813, 1823–29 (1984) (exploring limitations to patent grants under Antitrust Doctrine and the Sherman Act).

132 Johnson, *supra* note 25, at 292–93.

133 *Id.* at 293–96.

134 *Id.* at 295-96.

135 *Id.* at 297. Referring to a patent duration that is social-welfare-maximizing.

economic data.[136] To illustrate, I describe below two patent duration manipulation mechanisms.

1. Shorter Fixed Terms with an Option to Extend Based on Merit

Professor Scherer proposed a system of shorter patent durations where the government could grant inventors term extensions if the inventors proved their invention deserved greater protection.[137] To qualify for such extensions, inventors would have the burden of showing their inventions met certain conditions.[138] Examples of these conditions would include instances where the "market [wa]s small relative to the costs of research, or [where] the cost savings achieved were modest in relation to research costs."[139] This system's premise is that, given the uncertainty of determining a patent's ultimate value to society *ex ante*, the government can reduce incurring unnecessary deadweight loss by initially granting shorter duration patents.[140] This system is similar to Professor Johnson's fourth example of "Presumptions and Burden-Setting in an Adversarial Proceeding."[141]

One benefit from this system is that, by reducing the term of patent grants, the inventions that "would be lost would be primarily those inventions with relatively low benefit-cost ratios—those which in any event are not likely to have a great impact on social welfare."[142] Some limitations of Professor Scherer's model are that it results in increased transactional costs from renovation petitions and hearings, it potentially implicates indefinite duration terms that complicate calculating a patent's value,[143] and

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136 *Id.* at 302–08.

137 Scherer, *supra* note 5, at 427 (describing how a "best of both worlds" policy could "be achieved through a flexible system of compulsory licensing, under which the patent recipient bears the burden of showing why his patent should not expire or be licensed at modest royalties to all applicants three or five years after its issue").

138 More precisely, patentees would be able to overcome the burden by "demonstrat[ing] that [their] invention fell into one or more of the categories in which longer protection is needed to satisfy the Lebensraum condition." *Id.*

139 On the other hand, "[w]hen a [patentee] possesse[d] a substantial share of the relevant market and [had] well-established marketing channels, . . . there would be a presumption [against the patentee] that positive innovation profits could normally be attained without the added inducement of strong patent protection." *Id.*

140 *Id.* at 426–27 (pointing to how in certain circumstances, such as "[w]hen market concentration is high and nonpatent barriers to new entry are present, . . . [a] uniform policy of long-lived patent grants [will] confer[] excessive private rewards.").

141 Johnson, *supra* note 25, at 305–06.

142 Scherer, *supra* note 5, at 426.

143 Indefinite patent terms are problematic because, in cases where competing firms rely on these expiry terms to introduce competing products, indefinite terms may result in delays. *See* Johnson, *supra* note 25, at 287 (explaining how compulsory licensing would reduce patentee rewards by allowing competitors to gain manufacturing and marketing experience during the patent term and not after the patent term's expiry, hence reducing monopoly effects).

it potentially disincentivizes inventors from innovating because of the uncertainty in recouping their development costs in a shorter time frame.[144] One other limitation of Professor Scherer's model is that, because he bases his model on two utilitarian-focused variables, *percentage of cost reduction* and *dollars of research costs*,[145] it fails to account for behavioral factors.

2. Duration Based on Time-to-Market

Another researcher, Professor Benjamin N. Roin, proposed a system where patent duration is determined based on an invention's "time-to-market."[146] Professor Roin defines time-to-market as "the time it takes to move from the initial idea to its first sale as a commercialized product."[147] Time-to-market, in turn, is a "reliable indicia" of an invention's R&D costs, risks of failure, anticipated future revenue streams, and potential for imitation by rivals.[148] Time-to-market acts as a proxy for calculating the amount of patent protection needed to incentivize innovation.[149] This model is akin to Professor Johnson's second example, "Presumptions and Burden-Setting in an Adversarial Proceeding," where administrative agencies balance industry and societal interests to prescribe specific patent durations.[150]

Professor Roin's model's strength is that it proposes a unit of measurement that may be more indicative of an inventor's economic incentives than development costs alone.[151] Because time-to-market involves

[144] *Id.* at 298. Professor Scherer contemplated one such scenario—inventions involving *extraordinary* risk and uncertainty that require the inventor to take "unusually bold, farsighted, time-consuming departures from orthodox technology" and where an "exceptional reward . . . may be necessary to induce investment." Scherer, *supra* note 5, at 427. In such scenarios, Professor Scherer volunteers his system "be waived upon a showing that the patent recipient exhibited exceptional creativity or undertook unusual technical and/or commercial risks in the invention's development." *Id.* Although when Professor Scherer published his note in 1972, he believed such cases to be "rare" (*i.e.*, embracing not more than a dozen or so major inventions per year), these exceptions would likely be more common in the present and implicate many of the new drugs in the pharmaceutical industry. *Id.*

[145] *See* Scherer, *supra* note 5, at 422.

[146] Roin, *supra* note 3, at 727–34.

[147] *Id.* at 684. He posits using time-to-market as a proxy for optimal patent strength. *Id.* In turn, patent duration (length) can be used as a policy lever to tailor patent awards to match time-to-market. *Id.* at 754 ("Perhaps the easiest way to tailor patent awards based on time-to-market would be through a variable patent term, since patent length is the least complicated policy lever in patent law").

[148] *Id.* at 684.

[149] *Id.*

[150] Johnson, *supra* note 25, at 305-06.

[151] Unlike Professor Scherer's earlier model, which factored in only development costs, Scherer, *supra* note 5, at 422, the time-to-market model factors in four variables that affect optimal patent strength—"(1) R&D costs, (2) the risk of failure, (3) the anticipated revenue streams from the invention, and (4) the existence of other barriers to competitive imitation (particularly imitation costs)." Roin, *supra* note 3, at 698–99.

development costs and risks for failure, this model would be better able to internalize the pharmaceutical industry's extreme circumstances of high development costs and low likelihood of success.[152] Accounting for risk of failure is particularly important in the pharmaceutical industry because R&D investments "tend to focus on new therapeutic targets, which are characterized by high uncertainty and difficulty, but [will have] lower expected post-launch competition."[153] The model also potentially internalizes other industry-specific differences, such as subsequent innovation, and accounts for industry-specific differences regarding product life cycles.[154] As in Professor Scherer's model, Professor Roin's model does not account for industry-specific noneconomic, behavioral factors.

These two systems represent improvements over the current system in that they address a commonly criticized shortcoming of the present patent system—granting patents of standardized length to all inventions and potentially incurring an overpayment for inventions. However, because both systems are utilitarian-focused, they also share the limitation that they do not account for behavioral factors that affect innovation incentives, such as inventor myths or social legitimization. One model that researchers have not contemplated in-depth in the literature but that could potentially be helpful for factoring into many of the essential variables associated with patent duration is an automatic or semi-automatic algorithmic model.[155]

III. LEVER MANIPULATIONS: ONE ALGORITHM TO RULE THEM ALL

Algorithms are a relatively new concept in the law, but they have gained popularity as researchers use them to examine legal doctrines or quantify legal notions.[156] At least one research group has used an algorithm to predict patentability by calculating quantitative values for nonobviousness.[157] Similarly, researchers can theoretically apply algorithms to prescribe optimal patent duration based on a predefined set of empirical values.[158] The

[152] The time-to-market model calculates the pharmaceutical industry to have an average time-to-market of 12 to 16 years, the second-highest after "[f]uel cells." Roin, *supra* note 3, at 717–22, 728.

[153] Fabio Pammolli et al., *The Productivity Crisis in Pharmaceutical R&D*, 10 NATURE REV. DRUG DISCOVERY 428, 436 (2011).

[154] Roin, *supra* note 3, at 685, 735–38.

[155] *See* Johnson, *supra* note 25, at 306–08.

[156] *See* Laura G. Pedraza-Fariña & Ryan Whalen, *A Network Theory of Patentability*, 87 U. CHI. L. REV. 63, 104–36 (2020) (developing an empirical, algorithmic measure of patentability based on the authors' network theory of innovation).

[157] *Id.*

[158] Johnson, *supra* note 25, at 306–08; *see also* Pedraza-Fariña & Whalen, *supra* note 156, at 63–75 (detailing how the authors used patent classification records to calculate "network nonobviousness score"

government can use this calculated value as actual patent duration[159] or as a presumptive duration that the inventor can either agree to or use as a basis for negotiations with an administrative agency to determine the actual duration in an adversarial proceeding.[160]

A. Defining and Establishing Boundaries for Industry-Specific Classifications Using an Algorithm

Any model proposing to tailor patents across industries differentially will inevitably run into classification issues related to "properly sorting inventions into discrete categories [because t]he dividing lines . . . are porous and change over time, and many inventions fall within multiple distinct technological categories."[161] As a corollary to this issue, any model that separates patents into categories with differential patent durations will "inevitably [run into] line-drawing disputes."[162] As Professor Roin points out, "[u]nless the government can resolve the inevitable line-drawing questions based on the relevant economic characteristics of the inventions at issue (as opposed to their technological characteristics), firms will be able to draft their patents so that they fall within the categories offering more

(NNOS) indices based on technology combination frequencies to "design a prescriptive, doctrinal legal test").

159 Professor Johnson suggests a system where Congress uses the current 20-year term as a starting point and then "slowly adjust[s] the duration up or down until the desired level is reached." Johnson, *supra* note 25, at 307–08. Changes to the patent term "would be slow, so as not to shock any industrial sector [and, p]erhaps durations could change by no more than one year on an annual basis." *Id.* at 307–08.

160 Implementing the concepts from Professor Scherer's model, Scherer, *supra* note 5, at 427, I propose that, instead of using the algorithmic computation as an end value for a patent's duration, Congress or the USPTO can use this algorithmic computation as an initial value for negotiations. Because this value is based on empirically-backed data and not on a fixed 3- or 5- year term, as Professor Scherer suggested, *id.*, many of the limitations identified with the system would be mitigated, such as increased transactional costs, potential disincentivizing, and indefinite duration. Presumably, patentees would be more amenable to these calculated values and less inclined to appeal. At the same time, inventors with socially valuable inventions would have the option to appeal for longer terms, as necessary. Further, the patent term would be defined *ex ante* in a single hearing to prevent indefinite or uncertain patent durations.

161 Roin, *supra* note 3, at 710 (citations omitted). To illustrate the issue, Professor Roin points to an invention for "brain-computer interface technology, which may be akin to software, computer hardware, other electronics, medical devices, diagnostics, video game technology, or any other field that is likely to use these inventions." *Id.*

162 *Id.* at 755. As Professor Roin points, when sorting into categories where patent duration will be affected, "[p]atent applicants [can] take advantage of the ambiguous boundaries between technologies by drafting their patent claims to select into favored categories." *Id.* at 710. "For example, when courts initially prohibited pure software patents, patentees responded by drafting software claims as 'computer systems' that implemented software to get around the restriction. Likewise, when the PTO created a 'second look' program for business method patents to provide for a more rigorous examination process, patent applicants simply reframed their business-method claims so they could file their application in a different PTO division." *Id.* (citations omitted).

protection."[163] To overcome these classification issues under the time-to-market model,[164] Professor Roin suggests the government devise "technology-specific categories to minimize the number of line-drawing disputes—either by sorting inventions into fewer categories or using technology-specific laws with clearer boundaries."[165] In cases where disputes remain over an invention's class, the government can then analyze on a case-by-case basis.[166]

Building upon this principle from the time-to-market model, an algorithm based on empirical data of an invention's relevant economic characteristics[167] could potentially define such technology-specific categories and adjust patent duration based on an inventor's specific cluster.[168] Presumably, because such an algorithm would have data from various economic factors and not just time-to-market, it would be able to discern these technology-specific clusters more acutely.[169]

For example, inventions made by Tesla, a company that produces and sells electric vehicles, under a traditional model would be classified in the "Automobile" industry based on its type of business.[170] However, the company's research and development ("R&D") activities and business model have more in common with the Tech industry than with the Automobile industry.[171] Under the algorithmic model, the algorithm would

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163 *Id.* at 707.

164 The time-to-market model assumes that this factor, an invention's time-to-market, internalizes these technology-specific variabilities so that the government can use this metric to "judge which industries or classes of technology need more protection than others." *Id.* at 711.

165 *Id.* at 755.

166 *See id.* At 725. These case-by-case analyses, however, add transactional costs. *See id.*

167 *Id.* at 755.

168 The time-to-market model proposes categorizing inventions based on R&D times and industries with lengthy R&D times having a "highly gradated system of tailored patent awards" and industries with short R&D times having "minimal tailoring." *Id.* at 756.

169 One researcher, Professor Kimberly Moore (now, Chief Circuit Judge for the U.S. Court of Appeals for the Federal Circuit), collected empirical data from all utility patents issued by the USPTO in 1991 (96,713) and, when classifying by technology, pointed to the shortcomings of the USPTO's technology classification system. Moore, *supra* note 39, at 1529 n.35. "In addition to the problems inherent in broad technology classifications (for example, pharmaceutical and medical device patents are grouped together and may be very different in nature) . . . another shortcoming of this classification system is [that it is] based on the PTO technology classification system, [which] commentators have observed do[es] not group all similar technology together and as a result, may not be ideal for distinguishing among technologies." *Id.*

170 There is no such "Automobile" classification category, and this comparison is for representational purposes only. The USPTO classification system is based on the Cooperative Patent Classification Scheme. *European Patent Office & United States Patent Office*, COOPERATIVE PATENT CLASSIFICATION, http://www.cooperativepatentclassification.org/index.html [https://perma.cc/R32F-XMYZ]. Under this system, the USPTO would classify a general vehicle invention under class "B60." *Id.*

171 Bruno Aziza, *Why Tesla is Not a Car Company and What You Can Learn From Elon Musk*, FORBES (May 20, 2019, 1:18 AM), https://www.forbes.com/sites/ciocentral/2019/05/20/why-tesla-is-

analyze different sets of empirical data, including R&D expenses,[172] and classify Tesla based on these data variables instead of solely on the industry of the type of good sold.[173] Potentially, the algorithm could classify the company in a technology-specific (*sui generis*) category along with other similar companies in manufacturing industries that have significant R&D expenses and reliance on technology.[174]

Once the algorithm has determined proper classes for categorizing inventors, the next step would be to identify input variables for the algorithm for calculating patent duration. At least one variable should be financial and account for development costs and ancillary benefits.[175] Another variable should be noneconomic and at least account for the prevalence of inventor myths and social legitimization.[176]

B. Economic Variables in an Algorithmic Model

Patents are premised on the principle that they allow inventors to overcome the FRD and incentivize innovation by generating a producer surplus equal to or greater than the invention's development costs.[177] Under the algorithmic model, the algorithm would adjust this producer surplus, as determined by patent duration, to create welfare-maximizing conditions

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not-a-car-company-and-what-you-can-learn-from-elon-musk/?sh=fe640dc2d795 [https://perma.cc/XHE5-X27Y]; Tyler Clifford, *Jim Cramer Calls Tesla a 'Tech Company,' Says 2020 Is Its 'Breakout Year'*, CNBC (Jan. 22, 2020, 6:58 PM), https://www.cnbc.com/2020/01/22/jim-cramer-calls-2020-a-breakout-year-for-tech-company-tesla.html#:~:text=Tesla%20is%20a%20technology%20enterprise,a%20tech%20company%20on%20wheels [https://perma.cc/THF2-BPLB].

[172] Roin, *supra* note 3, at 684.

[173] Johnson, *supra* note 25, at 306–08. Other data that could potentially be fed into the algorithm is "innovation activity, patent effectiveness, incentives, and loss to social welfare." *Id.*.

[174] The exact composition of these categories would be subject to the economic data fed into the algorithm, with more data likely resulting in more graded classes. For example, one other company that could be in a similar category as Tesla is JUUL Labs, Inc. ("JUUL"). JUUL is a "Tobacco" company that manufactures nicotine vapes, but its research and development model more closely resemble a Tech company. *See Patents, Trademarks, Copyrights*, JUUL LABS, INC., https://www.juul.com/intellectual-property-list [https://perma.cc/Q2PP-MCEJ]; Kim Lyons, *New Juul Patent Application Hints at AI-Powered Vape to Help Users Quit Nicotine*, THE VERGE (Feb. 25, 2020, 1:28 PM), https://www.theverge.com/2020/2/25/21152436/juul-patent-e-cigarettes-vaping-ai-smartphone-quit-nicotine [https://perma.cc/BZ8E-LQ3A]; Scott Graham, *Juul Seeking Broad Order to Exclude Look-Alike E-Cigarettes*, THE RECORDER (Jul. 13, 2020, 9:02 PM), https://www.law.com/therecorder/2020/07/13/juul-seeking-broad-order-to-exclude-look-alike-e-cigarettes/ [https://perma.cc/U4WH-87BT].

[175] *See supra* Section II.A.1.

[176] *See supra* Section II.A.2.

[177] Johnson, *supra* note 25, at 270 ("Patents and copyrights are our society's flagship vehicles for overcoming the free-rider dilemma [and, b]y granting a term of monopoly rights in the form of a patent, the government provides a mechanism for innovators to appropriate their returns from R&D expenditures"); *see also* Fisher, *supra* note 19, at 4–6.

(optimal patent length).[178] To determine optimal patent length, the algorithm would need to account for variables that affect an inventor's development costs or barriers to appropriating returns, such as R&D expenses, risks of failure, anticipated revenue streams (if successful), and the potential for imitation.[179] Alternatively, the algorithm could simply account for an invention's time-to-market, which internalizes these four factors in a single metric.[180]

In addition to the actual producer surplus that patentees receive from their patents, patentees also receive intangible benefits unaccounted for in the Patent Incentive Theory.[181] Some of these intangible benefits include blocking technologies with patents, patent mining, and defensive patents.[182] The algorithm would need to account for these variables. For example, in industries with a high percentage of patent mining or blocking patents, the algorithm could curtail patent duration for inventors that were already receiving benefits from these practices.

C. Behavioral Variables and Other Intangibles in an Algorithmic Model

Behavioral factors play a role in incentivizing inventors to innovate. These behavioral factors vary based on the inventor's entity—whether a corporate entity or a human inventor[183]—and on the type of industry—industries with prevalent inventor myths will have stronger responses to nonbehavioral factors.[184] Given these factors' inherently qualitative values, empirical data regarding behavior is less available than quantitative economic data. The development of databases regarding behavioral innovation patterns would help generate empirical data to feed into the algorithm. Researchers can generate data via survey questions designed by

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178 Fisher, *supra* note 19, at 10 ("Ideally, patent duration or strength should be increased up to the point where the marginal benefits equal the marginal costs").

179 Roin, *supra* note 3, at 684 (The "optimal patent award for inventions is primarily a function of their R&D costs, the risk of failure in R&D, the anticipated future revenue streams from the projects if they succeed, and the potential for imitation by rivals").

180 *Id.* at 672 (positing "there is a strong, positive correlation between the amount of time needed to complete an R&D project and the amount of patent protection (if any) necessary to motivate investment in that R&D project [because a] longer time-to-market is associated with higher out-of-pocket R&D costs, greater risk of failure, increased opportunity costs of R&D investments, and diminished value of future revenue streams from the developed invention because of discounting").

181 *See supra* Section II.A.1.

182 *Id.*

183 Bair, *supra* note 35, at 318.

184 *See supra* Section II.A.2.

qualified psychologists. These surveys should at least address two themes linked to innovation incentives—personal motivation and inventor myths.[185]

CONCLUSION

Although patents likely do incentivize certain kinds of innovation and inventors would not have discovered some present inventions absent the prospect of a patent grant, many other such inventions and innovations would have been discovered independent of the prospect of a patent. Because society bears a cost for each patent that the USPTO grants to inventors, all such inventions that would have been discovered without a patent or with lesser patent rights result in a net loss to society. Since a patent's ultimate purpose is to generate social welfare, Congress should adjust the existing patent system so that patents produce social welfare-maximizing outcomes. One way to accomplish this is by adjusting the patent term to match the amount necessary to incentivize an inventor to innovate but that will not result in unnecessary societal deadweight loss. This equilibrium point is a patent's optimal term.

To determine a patent's optimal term, Congress must account for economic and behavioral factors. Under the time-to-market model—generally under the Patent Incentive Theory—four essential factors for determining optimal duration are an invention's R&D costs, risks of failure, anticipated future revenue streams, and potential for imitation by rivals. Similarly, under the new institutionalism framework—generally under the Behavioral Economic Theory—two essential factors for determining optimal duration are the prevalence of inventor myths in an industry and the social legitimization value of patents in their respective industries.

Two noteworthy models that researchers have proposed for adjusting patent duration as a means for social welfare maximization are: (1) a model with shorter, fixed-term patents with an option for patentees to extend their patents upon a showing of cause; and (2) a model with a patent duration adjusted to the invention's time-to-market. A third and comparatively novel system for adjusting patent duration is a system that uses algorithms to calculate patent duration based on empirical data. I propose one such system where the USPTO uses an algorithm to calculate a presumptive patent duration based on economic and behavioral data, and a patentee has the option to either accept the terms or appeal in an adversarial proceeding for a

[185] *Id.* These two variables presumptively affect incentives to innovate amongst inventors. By measuring these two variables across industries, researchers may assess and quantify differences across industries to properly adjust patent durations. Alternatively, these responses may be inputtedu into the algorithm so that the algorithm uses these responses to assist in sorting inventions into technology-specific categories within industries. *Id.*

longer term upon a showing of cause. One advantage of this algorithmic model is that the algorithm can be designed to self-determine categorical boundaries for inventions based on the inventor's economic and noneconomic data and avoid invention misclassifications. Based on an invention's class and other empirical data, including an invention's time-to-market and other industry-specific behavioral factors, the algorithm can calculate a patent duration that produces social welfare-maximizing outcomes.