

# Patent Inequality

## Abstract

Using an original dataset of over 1,000,000 patents and empirical methods, we find that the patent system perpetuates inequalities between powerful and upstart firms. When faced with growing numbers of patents in a field, upstart inventors reduce research and development expenditures, while those already holding many patents increase their innovation efforts. This phenomenon affords entrenched firms disproportionate opportunities to innovate as well as utilize the resulting patents to create barriers to entry (e.g., licensing costs or potential litigation).

A hallmark of this type of behavior is securing large patent holdings to create competitive advantages associated with the size of the portfolio, *regardless of the value of the underlying patents*. Indeed, this strategy relies on quantity, not quality. Using a variety of models, we first find evidence that this strategy is commonplace in innovative markets. Our analysis then determines that innovation suffers when firms amass many low-value patents to exclude upstart inventors. From these results, we not only provide answers to a contentious debate about the effects of strategic patenting, but also suggest remedial policies to foster competition and innovation.

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# Patent Inequality

## Introduction

Patent rights do not benefit all inventors the same.<sup>1</sup> In fact, the patent system might favor certain classes of inventors while frustrating others. This could explain why markets known for complex technologies tend to lack more than a few dominant competitors. Viewing the smartphone industry, four firms (Apple, Samsung, LG, and Motorola) account for 90% of all U.S. sales despite the rewards available in this market.<sup>2</sup> Perhaps the issue is that powerful corporations often maintain a large number of related patents, known as an “arsenal,” which offers strategic advantages against upstart competition.<sup>3</sup>

Consider the mechanics of this strategy. The sheer number of patents in a firm’s arsenal—*even if the patents are essentially worthless*—can substantially raise a rival’s costs to bring a product to market, thereby diminishing the incentives to conduct research.<sup>4</sup> An upstart firm entering the Bluetooth market, for example, must either identify and design around 30,000 patents

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<sup>1</sup> The purpose of patent law is to enhance the incentives to innovate. Without this system, actors would struggle to profit from the innovation process because third parties could copy and sell one’s invention while avoiding the cost of developing it. Patent law overcomes this problem by granting inventors the exclusive rights to make, use, or sell their novel goods and methods. In elevating the rewards of innovating relative to copying, the patent system is ultimately intended to increase the incentives of innovating relative to copying. *King Instruments Corp. v. Perego*, 65 F.3d 941, 950 (Fed. Cir. 1995) (“[T]he Patent Act creates an incentive for innovation. The economic rewards during the period of exclusivity are the carrot. The patent owner expends resources in expectation of receiving this reward.”); *see also* *Polymer Techs., Inc. v. Bridwell*, 103 F.3d 970, 976 (Fed. Cir. 1996) (“The right to exclude others from a specific market, no matter how large or small that market, is an essential element of the patent right.”)

<sup>2</sup> *US Smartphone Market by Share*, COUNTERPOINT, <https://www.counterpointresearch.com/us-market-smartphone-share/> (last accessed Jan. 25, 2019).

<sup>3</sup> A holding of patent is commonly called a “portfolio.” We use the term arsenal throughout this article because a portfolio does not necessarily entail a significantly large holding. The use of the term “arsenal” adds nuance by referring only to large holdings which typically provide strategic advantages. Kyle R. Kroll, *Anticompetitive Until Proven Innocent: An Antitrust Proposal to Embargo Covert Patent Privateering Against Small Businesses*, 100 MINN. L. REV. 2167, 2175 (2016) (“Privateering comprises two core activities: the aggregation and litigation of patents. Aggregation is the amassing of ‘vast treasuries of patents’ and forming a patent arsenal. The aggregation of thousands of patents shifts the focus from the value of one patent to the size and diversity of a portfolio, which can be wielded like a club and pose a substantial threat to litigation targets facing hundreds of infringement allegations at once.”). Colleen V. Chien, *From Arms Race to Marketplace: The Complex Patent Ecosystem and Its Implications for the Patent System*, 62 HASTINGS L.J. 297, 299 (2010) (“Among the many reasons high-tech companies get patents, one of the most important is to build a patent arsenal.”). *See generally* Julien Penin, *Strategic Uses of Patent in Markets for Technology: A Story of Fabless Firms, Brokers, and Trolls*, 84 J. ECON. BEHAVIOR & ORG. 633 (2012).

<sup>4</sup> Jonathan M. Barnett, *Has the Academy Led Patent Law Astray?*, 32 BERKELEY TECH. L.J. 1313, 1321–22 (2017).

or purchase blanket licenses to essential and extraneous patents alike.<sup>5</sup> Owners of large holdings can also threaten infringement litigation as a means of discouraging competition, as the cost to defend an infringement lawsuit averages around \$3,000,000.<sup>6</sup> Another strategic benefit of an arsenal is to dissuade rivals from using their own patents offensively; by acquiring a war chest of patents, a firm can ward off potential lawsuits via the threat of a countersuit.<sup>7</sup>

To critics, the rise of strategic patenting contravenes the patent system's purpose of "promot[ing] the Progress of Science and useful Arts."<sup>8</sup> Because a firm's arsenal is made effective by the quantity, rather than quality, of patents within it—as the task of inspecting multiple thousands of patents is virtually impossible—it is common to stockpile arsenals with low-value patents. In turn, a firm's arsenal might disregard the patent's utilitarian function—i.e. to protect an invention from misappropriation—as little of value is actually being secured. Instead, by increasing the costs and risks of innovation,<sup>9</sup> strategic patenting erects artificial barriers to entry, discouraging competitors from entering the market and conducting research. For instance, the roughly 250,000 patents enforced by the dominant smartphone companies have rendered it nearly impossible for others to challenge the iPhone or Samsung Galaxy.<sup>10</sup> So the concern is *not* whether firms are asserting legitimate patent rights against infringing technology, but whether the strategic

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<sup>5</sup> See generally Colleen V. Chien, *From Arms Race to Marketplace: The Complex Patent Ecosystem and Its Implications for the Patent System*, 62 HASTINGS L.J. 297, 322-23 (2010) (explaining offensive patenting).

<sup>6</sup> Debra Cassens Weiss, *\$2.5B Verdict Is Largest Patent Infringement Award in US History; Will Be Tripled?*, ABA J. (Dec. 19, 2016), [http://www.abajournal.com/news/article/2.5b\\_verdict\\_is\\_largest\\_patent\\_infringement\\_award\\_in\\_us\\_history\\_will\\_a\\_ward](http://www.abajournal.com/news/article/2.5b_verdict_is_largest_patent_infringement_award_in_us_history_will_a_ward) See Gregory Day, *Competition and Piracy*, 32 BERKELEY TECH. L.J. 775, 777-78 (2017) (explaining the hyper-compensatory nature of patent law).

<sup>7</sup> In the situation where the owner of a patent arsenal "is the potential infringer, the chances that the holder will have a cognizable counterclaim based on one or more of its own patents is much higher, especially if the patent portfolio in question covers a significant portion of the technological landscape - again, encouraging settlement rather than litigation." Gideon Parchomovsky & R. Polk Wagner, *Patent Portfolios*, 154 U. PA. L. REV. 1, 34 & n.119. And regardless of the responsive suit's outcome, substantial injury will be sustained through attorney's fees. The average patent lawsuit costs millions of dollars in attorney's fees. James Bessen & Michael J. Meurer, *The Private Costs of Patent Litigation*, 9 J.L. ECON. & POL'Y 59, 91 (2012); Michael J. Burstein, *Patent Markets: A Framework for Evaluation*, 47 ARIZ. ST. L.J. 507, 533 n.150 (2015).

<sup>8</sup> U.S. Const. art. I, § 8, cl. 8 ("The Congress shall have Power . . . To promote the Progress of Science and useful Arts, by securing for limited Times to Authors and Inventors the exclusive Right to their respective Writings and Discoveries").

<sup>9</sup> Dan L. Burk & Mark A. Lemley, *Policy Levers in Patent Law*, 89 VA. L. REV. 1575, 1627 (2003); Barnett, *supra* note 4, at 1322-23 ("[T]he issuance of large numbers of patents held by large numbers of owners is likely to depress innovation by burdening innovators with significant transaction costs relating to dispute resolution or licensing activities. . . . If those costs are sufficiently high, then a large part of the value generated by the innovation is dissipated, which, in the extreme case, causes the transaction to terminate because net expected value has fallen to zero or below.").

<sup>10</sup> *Too Many Patents*, PATENT PROGRESS, <https://www.patentprogress.org/systemic-problems/too-many-patents/> (last accessed Jan. 25, 2019).

collection of patents—low-value or otherwise—impedes firms from even attempting to compete and innovate.

But to industry advocates, since the driving motivation of most inventors is economic,<sup>11</sup> any use of patent rights that inures benefits onto the inventor generates incentives to innovate.<sup>12</sup> Further, recognizing that few inventions are ultimately profitable, the commodification of patent rights may enable inventors to recoup investment, which encourages firms to undertake risky yet important research and development (“R&D”) projects.<sup>13</sup> According to Maureen Ohlhausen, former Commissioner of the Federal Trade Commission, “allowing inventors to capture more of the social value of their discoveries induces them to devote more capital to R&D.”<sup>14</sup> In essence, then, the ability to extract value from a patent, even if the invention protected by the patent is worthless, might make the innovation process a more attractive venture.<sup>15</sup>

Illustrating this debate is the vigorous contention regarding whether the pharmaceutical company AbbVie promotes or thwarts innovation. AbbVie makes the world’s most profitable drug, Humira,<sup>16</sup> which costs about \$50,000 per patient annually.<sup>17</sup> As Humira’s patent approaches expiration, rival pharmaceutical companies have planned to make biosimilar versions of the drug, which would threaten AbbVie’s monopoly.<sup>18</sup> In response, AbbVie has sought to patent all aspects of Humira’s manufacturing process, asserting that Humira “represents true innovation in the field of biologics” and thus demands strong intellectual property (“IP”) protection.<sup>19</sup> Critics including

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<sup>11</sup> Marshall Phelps, *Do Patents Really Promote Innovation? A Response to the Economist*, FORBES (Sept. 16, 2015, 2:42PM), <https://www.forbes.com/sites/marshallphelps/2015/09/16/do-patents-really-promote-innovation-a-response-to-the-economist/#17bfcca21921>

<sup>12</sup> See Kristina M. L. Acri, *How to Promote Innovation: The Economics of Incentives*, IP WATCHDOG (Jul. 21, 2014), <http://www.ipwatchdog.com/2014/07/21/promote-innovation-the-economics-of-incentives/id=50428/> (arguing that decreasing the economic value of certain inventions reduces the incentives to innovate *but see* *Graham v. John Deere Co.*, 383 U.S. 1, 6 (1966) (discussing social benefits associated with patenting)).

<sup>13</sup> Phelps, *supra* note 11.

<sup>14</sup> Maureen K. Ohlhausen, *Patent Rights in a Climate of Intellectual Property Rights Skepticism*, 30 HARV. J.L. & TECH. 1, 3 (2016).

<sup>15</sup> Kevin Madigan, *An Ever Weakening Patent System Is Threatening the Future of American Innovation*, CPIP (Apr. 28, 2017), <https://cpip.gmu.edu/2017/04/28/an-ever-weakening-patent-system-is-threatening-the-future-of-american-innovation/> (noting “a conversation with the managing director of a private equity firm with \$10 billion in assets in which they discussed the past successful sale of a company based largely on its strong patent portfolio. The two agreed that the transaction would never have happened today due to the immeasurable decline in the value of patents.”).

<sup>16</sup> *Moderate to Severe Rheumatoid Arthritis*, HUMIRA, <https://www.humira.com/rheumatoid-arthritis> (last visited Dec. 10, 2018) (explaining that the drug treats forms of arthritis, colitis, and Crohn’s disease, among others).

<sup>17</sup> Cynthia Koons, *The Shield of Patents Protects the World’s Best Selling Drug*, BLOOMBERG (Sept. 7, 2017, 6:00AM), <https://www.bloomberg.com/news/articles/2017-09-07/this-shield-of-patents-protects-the-world-s-best-selling-drug>

<sup>18</sup> Stephanie Goldberg, *How Valuable Is a Post-Humira AbbVie*, CHICAGO BUS. (Nov. 2, 2018, 2:29PM), <https://www.chicagobusiness.com/health-care/how-valuable-post-humira-abbvie>.

<sup>19</sup> Koons, *supra* note 17.

FDA Commissioner Scott Gottlieb contend, however, that AbbVie’s patenting strategy harms innovation, as it is “purely designed to deter the entry of approved biosimilar drugs.”<sup>20</sup> A current lawsuit has even pressed the novel claim<sup>21</sup> that AbbVie has “unclean hands” in collecting such a taxing group of marginal patents intended solely to frustrate rival invention.<sup>22</sup> So while the allure of patent rights likely led to Humira’s innovation, the other hundreds of patents derived from AbbVie’s manufacturing process might actually inhibit innovation.

The question of whether strategic patenting promotes or imperils innovation demands an answer given the social and economic costs of the patent system. A patent is considered a “limited monopoly” in the sense that no other party can employ the protected technology without a license from the patent owner.<sup>23</sup> Because these exclusive rights enable patentees to charge supracompetitive prices and resist pressures to improve quality,<sup>24</sup> the system must generate sufficient innovation to justify its deadweight loss.<sup>25</sup> Compounding matters, the sizeable cost of defending an infringement claim has incentivized a cottage industry of litigants who threaten

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<sup>20</sup> Peter Loftus & Denis Roland, *By Adding Patents, Drugmakers Keeps Cheaper Humira Copies Out of U.S.*, WALL ST. J. (Oct 16, 2018, 7:00AM), <https://www.wsj.com/articles/biosimilar-humira-goes-on-sale-in-europe-widening-gap-with-u-s-1539687603?ns=prod/accounts-wsj>

<sup>21</sup> The argument can be characterized as novel because patent owners like AbbVie are generally thought to enjoy antitrust immunity to assert their patent rights so long as their exclusionary conduct has occurred within the scope of a patent. Indeed, since a patent is considered to be a legally granted monopoly, most courts will only hold a patent owner liable for an antitrust violation if the exclusionary act exceed the patentee’s rights granted in the patent. This framework enables patent owners to use their patent rights to exclude as competitor without violating antitrust law. In terms of Boehringer’s lawsuit, the claim can be considered novel because enforcing one’s valid patent right is seldom considered to be an anticompetitive behavior beyond the scope of one’s patent rights. *King Drug Co. of Florence v. Smithkline Beecham Corp.*, 791 F.3d 388, 394 (3d Cir. 2015), *cert. denied*, 137 S. Ct. 446 (2016) (“A patent . . . is an exception to the general rule against monopolies and to the right to access to a free and open market.” (quoting *Walker Process Equip., Inc. v. Food Mach. & Chem. Corp.*, 382 U.S. 172, 177 (1965)); *FTC v. Watson Pharm., Inc.*, 677 F.3d 1298, 1308–09 (11th Cir. 2012) (“[A] patent gives its holder a ‘bundle of rights,’ but any new exclusionary rights the holder buys to add to that bundle do not fall within the scope of the patent grant and [thus] do not fall within the scope of the patent’s antitrust immunity.”).

<sup>22</sup> *AbbVie, Inc. v. Boehringer Ingelheim Int’l GMBH*, Civil No. 17-cv-01065-MSG-RL (D. Del.), available at <https://www.bigmoleculewatch.com/wp-content/uploads/2018/06/Abbvie-v.-BI-Memorandum-and-Order.pdf> (Boehringer’s defense and counterclaim allege a “global effort to improperly delay competition with respect to adalimumab” by pursuing “overlapping and non-inventive patents for the purpose of developing a ‘patent thicket[.]’” (citation and internal quotations omitted)); Eric Sagonowsky, *Look Out, AbbVie. Thanks to Boehringer, Your Humira Biosimilar Defense Isn’t Over Yet*, FIRECEPHARMA (Sept. 13, 2018, 11:25AM), <https://www.fiercepharma.com/pharma/abbvie-boehringer-battle-over-patents-for-world-s-biggest-drug>

<sup>23</sup> Kenneth J. Burchfiel, *Patent Misuse and Antitrust Reform: “Blessed Be the Tie?”*, 4 HARV. J.L. & TECH. 1, 7 (1991)

<sup>24</sup> Jeremy N. Sheff, *Self-Replicating Technologies*, 16 STAN. TECH. L. REV. 229, 241; Natasha N. Aljalian, *The Role Of Patent Scope In Biopharmaceutical Patents*, 11 B.U. J. SCI. & TECH. L. 1, 20 (2005).

<sup>25</sup> Keith Leffler & Cristofer Leffler, *Efficiency Trade-Offs in Patent Litigation Settlements: Analysis Gone Astray?*, 39 U.S.F. L. REV. 33, 35 (2004) (describing the tradeoff between dynamic and static efficiency offered by patent rights); W. Michael Schuster, *Rent-Seeking and Inter Partes Review: An Analysis Of Invalidity Assertion Entities In Patent Law*, 22 MICH. TELECOMM. TECH. L. REV. 271, 280 (2016).

meritless infringement lawsuits as a means of extracting rents from inventors—i.e., the “patent assertion entity,” also known as the “patent troll.”<sup>26</sup> So if the strategic use of patent rights impedes innovation, this poses a serious problem. Indeed, given the importance of innovation and costs imposed by strategic patenting, it is vital to determine whether the building of patent arsenals incentivizes innovation or erects artificial barriers to entry.

This Article presents empirical research on the social and economic effects of strategic patenting. When firms exploit patent rights in a manner that in no way protects a valuable invention, we find that the patent system impedes innovation, becoming unable to justify the costs it levies on society. In a particularly novel finding, the presence of patent arsenals *bolsters* the innovation efforts of the largest inventors while impeding R&D by smaller firms. Consider the implications of this: the strategy of maintaining large patent arsenals seems only to discourage small inventors, widening the gap between the powerful and not-so-powerful. Troublingly, some of the most vital forms of innovations stem from startup inventors who may find themselves excluded due to strategic patenting.<sup>27</sup> We thus shed light on the debate about whether the commodification of low-value patents increases innovation; it does not. Our research concludes that the costs generated by strategic patenting creates a net loss of innovation, especially harming upstart inventors.

To reach these results, we tested the decisions made by owners of over 1,000,000 patents spanning a ten-year period in a series of steps. First, we analyzed an underappreciated aspect of patent law: the maintenance fee (to prevent a patent from lapsing, a patentee must pay \$1,600, \$3,600, and \$7,400 at the patent’s fourth, eighth, and twelfth years, respectively).<sup>28</sup> The results demonstrate that firms wielding significant portfolios are especially likely to maintain their patents regardless of each patent’s quality, erecting artificial barriers to entry. Our second analysis finds similarly that firms endeavoring to build an arsenal are more willing to undergo costly patent prosecutions irrespective of the patent’s quality. From these results, we next test the systemic effects of strategic patenting. Instead of promoting innovation—as the patent system is meant to do—the rise of strategic arsenals erodes the incentives to innovate. Specifically, we show that

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<sup>26</sup> Mark A. Lemley & A. Douglas Melamed, *Missing the Forest for the Trolls*, 113 COLUM. L. REV. 2117, 2127 (2013).

<sup>27</sup> Clayton M. Christensen, *THE INNOVATOR’S DILEMMA: WHEN NEW TECHNOLOGIES CAUSE GREAT FIRMS TO FAIL* 134 (1997) (smaller organizations are better suited to created disruptive technologies); David Abrams & Polk Wagner, *Poisoning the Next Apple? The America Invents Act and Individual Inventors*, 65 STAN. L. REV. 517, 530 (2013) (“[T]here is some evidence that the inventions from smaller entities are more likely to be disruptive in nature, moving the pace of technological change forward.”); Amy L. Landers, *The Antipatent: A Proposal for Startup Immunity*, 93 NEB. L. REV. 950, 1004 (2015) (“[S]mall firms to lead the way for certain types of technological innovation.”); *Promoting Innovation in SMEs*, ORGANIZATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (2018), available at <https://www.oecd.org/cfe/smes/ministerial/documents/2018-SME-Ministerial-Conference-Parallel-Session-4.pdf>

<sup>28</sup> *USPTO Fee Schedule*, U.S. PATENT & TRADEMARK OFFICE, <https://www.uspto.gov/learning-and-resources/fees-and-payment/uspto-fee-schedule> (last accessed Dec. 10, 2018).

innovation in general, and by smaller firms in particular, wanes where firms aggressively maintain low-value patents.<sup>29</sup> If patentees allowed middling patents to lapse, we find strong evidence that this would encourage invention, reduce barriers to entry, and ward off meritless rent-seeking claims.

To effectuate our findings, we propose slight readjustments to the economics of inventing. Each proposal is meant to reduce the incentives to secure and upkeep marginal patents. By allowing the market to price the value of an invention rather than a patent's strategic qualities, our analysis informs logical yet modest reforms which should empower smaller inventors relative to their larger entrenched rivals.

This article proceeds in four Parts. Part I explains the manner in which the incentives to innovate offered by the patent system have evolved, causing inventors to modify their patenting strategies. In reviewing the relevant literature, this Part explores the rewards of strategically using patents to inhibit efforts by competitors to bring products to market or defend against similar efforts of others. In important part, we address the debate about whether the strategic commodification of patent rights harms or promotes innovation. Part II presents our expectations. We argue that firms with large patent holdings disproportionately value low-worth patents, as each patent belonging to a sizeable portfolio increases a competitor's barriers to entry. If firms with large holdings value individual patents as commodities, they should be more likely to pay the costs to obtain and maintain a patent regardless of quality. We next expect competitors—in the face of large patent holdings and associated difficulties in bringing products to market—to reduce R&D spending. In essence, it is our theory that the acts of patenting and innovating are distinct; in many instances, when patenting increases, innovation diminishes. Part III tests these and related hypotheses by analyzing individual decisions to secure and maintain patents, R&D expenditure patterns, and other observable behaviors. Part IV offers important yet modest proposals to increase innovation based upon our theory and empirical results.

## **I. Patents, Innovation, and Strategy**

Over the past few decades, actions by the courts and Congress have manipulated the strength of patent rights, causing firms to alter their patenting strategies. It is now common for companies to patent large numbers of small inventions, creating a significant increase in the number of patents in force.<sup>30</sup> This Part reviews the literature analyzing the manner in which these

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<sup>29</sup> See Clark D. Asay, *Patent Pacifism*, 85 GEO. WASH. L. REV. 645, 671 (describing low value software patents, though the attributes described are attributable in many instances).

<sup>30</sup> Chien *supra* note 5, at 304–07.



developments have influenced innovation so as to frame our theory of strategic patenting (found in Part II which we test in Part III).

### A. *Growth of Patent Value*

Modern debates about the value of patent rights find their genesis in the 1980s when patent activity swelled in the United States. During the preceding decade, investment in R&D stagnated, which many observers attributed to weak IP rights.<sup>31</sup> Congress responded by granting exclusive jurisdiction over patent appeals to the Federal Circuit in 1982<sup>32</sup> for the purpose of strengthening patent rights.<sup>33</sup> The act achieved its mandate.<sup>34</sup>

As a starting point, the Federal Circuit bolstered patent value by increasing a patent's likelihood of surviving litigation. Leading into the 1970s, litigation invalidated over 80 percent of patents,<sup>35</sup> and during the 1970s as a whole, the percentage stood at near two-thirds. This fate undermined the incentives to invent since an invalidated patent inures little benefit to its owner.<sup>36</sup> The Federal Circuit reversed this trend by, according to Lunney,<sup>37</sup> upholding a greater percentage of challenged patents.<sup>38</sup> Allison and Lemley likewise found that only 54% of patents were invalidated from 1989-1996.<sup>39</sup> Cotropia attributes this phenomenon to the Federal Circuit's relaxation of nonobviousness standards<sup>40</sup>—a hypothesis consistent with Lunney's research.<sup>41</sup>

The courts took additional steps that enhanced patent value by expanding the scope of patentable subject matter. As examples, near the Federal Circuit's creation, the Supreme Court

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<sup>31</sup> Testimony of Pauline Newman, FTC/DOJ Hearings 2/6/2002 at 39-42.

<sup>32</sup> 28 U.S.C. § 1295(a)(1); Mark A. Lemley, *The Surprising Resilience of the Patent System*, 95 TEX. L. REV. 1, 7 (2016).

<sup>33</sup> H.R. REP. NO. 97-312, at 20 (1981); *Markman v. Westview Instruments, Inc.*, 517 U.S. 370, 390 (1996); *see also* H.R. REP. NO. 4242, 97th Cong. (1981-1982) (creating tax incentives associated with research expenditures).

<sup>34</sup> Mark A. Lemley, *The Surprising Resilience of the Patent System*, 95 TEX. L. REV. 1, 7 (2016).

<sup>35</sup> *Carter-Wallace, Inc. v. Davis-Edwards Pharmacal Corp.*, 443 F.2d 867, 872 (2d Cir. 1971) (citing *Milgrim, Sears to Lear to Painton: Of Whales and Other Matters*, 46 N.Y.U. L. REV. 17, 31 & n.62 (1971)).

<sup>36</sup> John R. Allison & Mark A. Lemley, *The Growing Complexity of the United States Patent System*, 82 B.U. L. REV. 77, 140-41 (2002).

<sup>37</sup> F.T.C., *To Promote Innovation: The Proper Balance of Competition and Patent Law and Policy* 18 (Oct. 2003), <http://www.ftc.gov/sites/default/files/documents/reports/promote-innovation-proper-balance-competition-and-patent-law-and-policy/innovationrpt.pdf>.

<sup>38</sup> Glynn S. Lunney, Jr., *Patent Law, the Federal Circuit, and the Supreme Court: A Quiet Revolution*, 11 SUP. CT. ECON. REV. 1, 15 (2004).

<sup>39</sup> John R. Allison & Mark A. Lemley, *Empirical Evidence on the Validity of Litigated Patents*, 26 AIPLA Q. J. 185, 241 (1998).

<sup>40</sup> Christopher A. Cotropia, *Nonobviousness and the Federal Circuit: An Empirical Analysis of Recent Case Law*, 82 NOTRE DAME L. REV. 911, 913 (2007).

<sup>41</sup> F.T.C., *supra* note 37, at 18.

affirmed the patentability of engineered biological materials<sup>42</sup> and software.<sup>43</sup> Then, in 1998, the Federal Circuit ratified business method patents in *State Street Bank and Trust v. Signature Financial*.<sup>44</sup> Unsurprisingly, patenting in these areas increased.<sup>45</sup> Masur likewise attributes incremental expansions of patentable subject matter to applicants' right to seek Federal Circuit review of borderline cases.<sup>46</sup>

Further enhancing patent value, the Federal Circuit strengthened remedies for patentees who successfully alleged infringement. It initially imposed supra-compensatory damages on infringers,<sup>47</sup> alongside an almost immediate rise in the grant rate of attorney's fees.<sup>48</sup> The burden for victorious plaintiffs to secure injunctive relief was also lowered until the Supreme Court intervened in 2006.<sup>49</sup> And to assuage coordination problems, the courts rescinded antitrust law's limitations on IP licensing (e.g., the Nine No-Nos<sup>50</sup>) which had previously frustrated collaboration among rival patent owners.<sup>51</sup>

The 1980s also saw Congress expand patent rights, including enactments of the Drug Price Competition and Patent Term Restoration Act of 1984 (extending the term of some pharmaceutical

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<sup>42</sup> *Diamond v. Chakrabarty*, 447 U.S. 303 (1980).

<sup>43</sup> *Diamond v. Diehr*, 450 U.S. 175 (1981).

<sup>44</sup> 149 F.3d 1368 (Fed. Cir. 1998).

<sup>45</sup> Stuart J. H. Graham & David C. Mowery, *Intellectual Property Protection in the U.S. Software Industry* (2001); Josh Lerner, *Where Does State Street Lead? A First Look at Finance Patents, 1971-2000*, 57 J. FIN. 901-930 (2002); Nancy T. Gallini, *The Economics of Patents: Lessons from Recent U.S. Patent Reform*, 16 J. ECON. PERSP. 131, 131-154 (2002).

<sup>46</sup> Jonathan Masur, *Patent Inflation*, 121 YALE L.J. 470, 512 (2011) (describing an expansion of patentable subject matter due to the applicant's asymmetrical right of appeal, relative to the Patent Office).

<sup>47</sup> Brian J. Love, *The Misuse of Reasonable Royalty Damages as a Patent Infringement Deterrent*, 74 MO. L. REV. 909, 911 (2009).

<sup>48</sup> Brian D. Coggio, *Damage Control-What an Adjudged Infringer Can Do to Minimize the Resulting Damage*, 15 AIPLA Q.J. 250, 262 (1987); Alfred J. Mangels, *The Quiet Revolution in Patents*, 31 RES GESTAE 356 (1988). It is notable that approximately 25 years after its inception, the Federal Circuit would increase the standard for a finding of willful infringement in 2007. *See also* *In re Seagate Tech., LLC*, 497 F.3d 1360 (Fed. Cir. 2007) (en banc); Christopher B. Seaman, *Willful Patent Infringement and Enhanced Damages After in Re Seagate: An Empirical Study*, 97 IOWA L. REV. 417, 441 (2012).

<sup>49</sup> Lemley, *supra* note 34, at 57 (citing Ernest Grumbles III et al., *The Three Year Anniversary of eBay: A Statistical Analysis of Permanent Injunctions*, <http://www.merchantgould.com/portalresource/Three-Year-Arrniversary-of-eBay-v-MercExchange.pdf> [<https://perma.cc/F3NV-8RY3>]); *eBay Inc. v. MercExchange, L.L.C.*, 547 U.S. 388 (2006).

<sup>50</sup> W. Michael Schuster, Comment, *Subjective Intent in the Determination of Antitrust Violations by Patent Holders*, 49 S. TEX. L. REV. 507, 525 (2007).

<sup>51</sup> *Competition and Intellectual Property Policy: The Way Ahead*, 2001 WL 1470078, at \*1; Abbott B. Lipsky, *Current Antitrust Division Views on Patent Licensing Practices*, Remarks Before the American Bar Association Antitrust Section (Nov. 5-6, 1981).

patents),<sup>52</sup> Bayh-Dole Act of 1980 (increasing inventor rights for government-sponsored work),<sup>53</sup> and Stevenson-Wydler Technology Innovation Act of 1980 (facilitating technology transfer from government laboratories).<sup>54</sup> Taken as a whole, these activities bolstered patent value, prompting firms to alter their patenting and innovation strategies, which we discuss in the next section.

### *B. The Ensuing Surge in Applications and Patenting Activity*

The manner in which the courts and Congress enhanced patent value<sup>55</sup> altered fundamental strategies of inventors.<sup>56</sup> Perhaps the most glaring development was the rise in issued patents: from nearly 62,000 patents granted in 1980 to over 224,000 in 2011.<sup>57</sup> Bolstering this growth, diminished standards for patentability nudged inventors to file applications for increasingly marginal inventions.<sup>58</sup>

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<sup>52</sup> See generally 35 U.S.C. § 156 (2000 & Supp. II 2002).

<sup>53</sup> See generally 35 U.S.C. §§ 200-212 (2000 & Supp. II 2002).

<sup>54</sup> See generally 15 U.S.C. § 3710 (2000).

<sup>55</sup> See, e.g., Jon F. Merz & Nicholas M. Pace, *Trends in Patent Litigation: The Apparent Influence of Strengthened Patents Attributable to the Court of Appeals for the Federal Circuit*, 76 J. PAT. & TRADEMARK OFF. SOC'Y 579, 580 (1994).

<sup>56</sup> Knut Blind et al., *The Influence of Strategic Patenting on Companies' Patent Portfolios*, 38 RES. POL'Y 428, 434 (2009) (describing how, in the global market, “patent strategies have changed and became more complex and comprehensive,” leading to an expansion of patent applications).

<sup>57</sup> Evan J. Wallach & Jonathan J. Darrow, *Federal Circuit Review of U.S.P.T.O. Inter Partes Review Decisions, By the Numbers: How The AIA Has Impacted the Caseload of the Federal Circuit*, 98 J. PAT. & TRADEMARK OFF. SOC'Y 105, 105–06 (2016).

This acceleration of patent applications and grants was, however, not consistent across markets. Within complex technologies, the number of patents in force became disproportionately high due to the many patentable elements of complex products such as semiconductors and telecommunications. Markus Reitzig, *The Private Values of ‘Thickets’ and ‘Fences’: Towards an Updated Picture of the Use of Patents Across Industries*, 13 ECON. INNOVATIONS & NEW TECH. 457, 460 (2004). This is consistent with Hicks, et al. who found patenting of information technologies has significantly outpaced growth in other areas. D. Hicks et al., *The Changing Composition of Innovative Activity in the US—A Portrait Based on Patent Analysis*, 30 RES. POL'Y 681, 701 (2001). By contrast, patent filings and grants were less prolific in areas where discrete inventions dominate markets and incremental follow-on inventions are uncommon. An example is the pharmaceutical sector where a lone patent can create a substantial competitive advantage by excluding competitors from utilizing that particular drug. Bhaven N. Sampat, *When Do Applicants Search for Prior Art?*, 53 J.L. & ECON. 399, 401 (2010). The pharmaceutical market may, however, be moving from the “single patent” model, as shown by the AbbVie example discussed in the Introduction. See *supra* note 20 and related text.

<sup>58</sup> Gaétan de Rassenfosse & Adam B. Jaffe, *Are Patent Fees Effective at Weeding Out Low-Quality Patents?*, 27 J. ECON. & MGMT. STRATEGY 134, 144 (2018).

This expansion began a chain of events encouraging “patent portfolio races” among competitors.<sup>59</sup> Firms recognized that, in the face of easier to obtain patents, securing a large arsenal could deter competition. Consider that each patent within a firm’s arsenal decreases a competitor’s likelihood of producing a non-infringing product.<sup>60</sup> Likewise, quantity decreases uncertainty, as a court is unlikely to invalidate *every* patent in an arsenal, interpret them narrowly, or otherwise devalue the portfolio.<sup>61</sup> This landscape has created recognition among companies that a large patent holding offers strategic value—i.e., “the whole is greater than the sum of its parts”<sup>62</sup>—making arsenals the hallmark of strategic patenting.

One repercussion of strategic patenting was the creation of an “anti-commons,” defined as a dense web of interrelated patents held by many firms.<sup>63</sup> A related concept—the patent thicket—exists where many patents claim the same or similar technology—a situation that commonly occurs where multiple firms in an industry maintain substantial individual arsenals.<sup>64</sup> In the presence of a thicket or anti-commons (the terms are used synonymously herein), one product may incorporate technologies owned by several parties.<sup>65</sup> This leads to the Tragedy of the Anti-Commons,<sup>66</sup> a phenomenon wherein the cost to employ technology is prohibitively expensive because a firm must either license or design around many patents held by different parties to market a product.<sup>67</sup> And since a refusal to license IP can derail another’s plans to innovate, some patentees engage in “hold-out” behavior whereby they decline to license a necessary patent absent an exorbitant payment.<sup>68</sup> This landscape has generated an industry of patent assertion entities, patent

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<sup>59</sup> B.H. Hall & R.H. Ziedonis, *The Patent Paradox Revisited: An Empirical Study of Patenting in the U.S. Semiconductor Industry, 1979-1995*, 32 Rand J. Econ. 101, 105-108 (2001); Wesley M. Cohen, *Patents and Appropriation: Concerns and Evidence*, 30 J. TECH. TRANSFER 57, 62 (2005).

<sup>60</sup> Parchomovsky & Wagner *supra* note 7, at 36 & 39.

<sup>61</sup> *Id.* at 40-41.

<sup>62</sup> *Id.* at 40-41.

<sup>63</sup> Burk, *supra* note 9, at 1627.

<sup>64</sup> Carl Shapiro, *Navigating the Patent Thicket: Cross Licenses, Patent Pools, and Standard-Setting*, 1 INNOVATION POL’Y & ECON. 6 (2001); R. Polk Wagner, *Information Wants To Be Free: Intellectual Property And The Mythologies Of Control*, 103 COLUM. L. REV. 995, 997 n.6 (2003). Similar situations have been referred to as “anti-commons.” Michael A. Heller & Rebecca S. Eisenberg, *Can Patents Deter Innovation? The Anticommons in Biomedical Research*, 280 SCI. 698 (1998).

<sup>65</sup> *In re Qimonda AG*, 462 B.R. 165, 175 (Bankr. E.D. Va. 2011), *aff’d sub nom. Jaffe v. Samsung Elecs. Co.*, 737 F.3d 14 (4th Cir. 2013).

<sup>66</sup> Michael A. Heller & Rebecca S. Eisenberg, *Can Patents Deter Innovation? The Anticommons in Biomedical Research*, 280 SCI. 698, 699 (1998).

<sup>67</sup> de Rassenfosse, *supra* note 58, at 144; *Qimonda AG*, 470 B.R. at 377; Rebecca Eisenberg, *Noncompliance, Nonenforcement, Nonproblem? Rethinking the AntiCommons in Biomedical Research*, 45 HOUS. L. REV. 1059, 1073 (2008); Michael Noel & Mark Schankerman, *Strategic Patenting and Software Innovation*, 21 J. INDUS. ECON. 481, 483 (2013).

<sup>68</sup> Donna M. Gitter, *Resolving the Open Source Paradox in Biotechnology: A Proposal for a Revised Open Source Policy for Publicly Funded Genomic Databases*, 43 HOUS. L. REV. 1475, 1503 (2007).

trolls, and even market participants who use their patent portfolios to threaten litigation against practicing inventors as a means of extracting rents from them.<sup>69</sup>

The manner in which companies respond to patent thickets has exasperated these issues. Research finds that, in the presence of numerous patents, firms are likely to *increase* their rate of patenting<sup>70</sup>—a behavior which only strengthens thickets. While this approach might seem counterintuitive, it makes sense on the firm level. Because a company in the presence of an industry-wide thicket must secure hundreds of licenses to market a product, the typical firm will accumulate its own arsenal to cross-license with competitors (as opposed to paying for licenses).<sup>71</sup> For instance, Merus N.V. and Regeneron Pharmaceuticals agreed to cross-license patents on a royalty-free basis to resolve their lawsuits against each other.<sup>72</sup> Such negotiations can employ the “ruler” methodology, whereby two parties “put [their stacks of patents] next to each other and you'd take a ruler and you measure the relative heights of the stack, and some algorithm would tell you the [additional amount to be paid.]”<sup>73</sup> This landscape created a positive feedback loop whereby those who perceive their competitors to be strategically collecting patents mimic this behavior.<sup>74</sup> The result is a collective action problem in which all firms would benefit if they ceased mass

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This landscape has generated an industry of patent assertion entities, patent trolls, and even market participants who use their patent portfolios to threaten litigation against practicing inventors as a means of extracting rents from them. In re Packard, 751 F.3d 1307, 1325 (Fed. Cir. 2014) (explaining patent assertion entities and patent trolls); see generally Edward Lee, *Patent Trolls: Moral Panics, Motions in Limine, and Patent Reform*, 19 STAN. TECH. L. REV. 113, 119 (2015).

<sup>70</sup> B.H. Hall & R.H. Ziedonis, *The Patent Paradox Revisited: An Empirical Study of Patenting in the U.S. Semiconductor Industry, 1979-1995*, 32 RAND J. ECON. 101, 109-110 (2001); Wesley M. Cohen, *Patents and Appropriation: Concerns and Evidence*, 30 J. TECH. TRANSFER 57, 62 (2005); Entezarkheir, *supra* note 82, at 602. See also Rosemarie Ziedonis, *Don't Fence Me In: Fragmented Markets for Technology and the Patent Acquisition Strategies of Firms*, 50 MGMT. SCI. 804, 817 (2004) (asserting that firms with many patents tend to patent more); Noel, *supra* note 67, at 508-09 (asserting the large portfolios are worth more in fragmented markets).

<sup>71</sup> Wesley M. Cohen et al., *Protecting Their Intellectual Assets: Appropriability Conditions and Why U.S. Manufacturing Firms Patent (Or Not)*, 19-20 NAT'L BUREAU OF ECON. RES., Working Paper No. 7552 (Feb. 2000), <http://www.nber.org/papers/w7552> (finding that cross-licensing is more prevalent in complex industries where patent thickets tends to prevail).

<sup>72</sup> *Merus Announces Global Settlement and End to All Patent Litigation with Regeneron Pharmaceuticals*, GLOBE NEWS WIRE (Dec. 20, 2018, 4:45PM), <https://globenewswire.com/news-release/2018/12/20/1677353/0/en/Merus-Announces-Global-Settlement-and-End-to-All-Patent-Litigation-with-Regeneron-Pharmaceuticals.html>

<sup>73</sup> *The Evolving IP Marketplace: The Operation of IP Markets: The IP Marketplace in the IT Industry*, Hearing Before the F.T.C. 132 (May 4, 2009) (statement of Ron Epstein, Chief Executive Officer, Ipotential, LLC). Reitzig has even argued that cross licensing is now the “first-best use for a patent” in fields involving complex technologies. Reitzig, *supra* note 57, at 460.

<sup>74</sup> Colleen V. Chien, *From Arms Race to Marketplace: The Complex Patent Ecosystem and Its Implications for the Patent System*, 62 HASTINGS L.J. 297, 306 (2010) (discussing the idea of “demonstration effects”); see also See Shapiro, *supra* note 64; Gideon Parchomovsky & R. Polk Wagner, *Patent Portfolios*, 154 U. PA. L. REV. 1, 27 (2005).

patenting but refuse to do so for fear of exploitation.<sup>75</sup> Simply put, the presence of many patents in a field begets more patenting and thus thickets.<sup>76</sup>

### C. *The Debate*

Despite the innovation roadblocks erected by patent arsenals, the degree to which they pose a problem is disputed. Because the patent system is meant to create incentives to invent stemming from the right to exclude, some commentators assert that *any* value derived from this monopoly encourages firms to innovate.<sup>77</sup> For instance, given that most inventions are commercial failures, the economic benefits derived from strategic patenting help inventors to insure against a total loss of investment, thereby making the innovation process a safer venture.<sup>78</sup> Scholarship in support of this position includes Noel and Schankerman who found that patent thickets in the software industry caused firms to increase R&D spending.<sup>79</sup> Further, their research determined that patent accumulation increased company value and promoted knowledge spill-overs across the industry.<sup>80</sup> Barnett concluded that patent thickets force collaboration among competitors, which he argued is the reason complex technology markets are animated by high levels of innovation as well as low prices.<sup>81</sup> In this sense, increasing the value of an otherwise worthless patent fosters innovation.

But on the other hand, empirical research finds that patent thickets decrease innovation and firm value even when accounting for costs saved via a firm's own strategic activities.<sup>82</sup> In the field of biomedical research, Heller and Eisenberg concluded that widespread patenting fragmented the field<sup>83</sup> and discouraged R&D.<sup>84</sup> Other scholarship has evaluated the effects of broad patenting in fragmented markets (e.g., situations with *many* different patent owners) for software companies during the 80s and 90s, concluding that firm value decreases with participation in this market.<sup>85</sup>

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<sup>75</sup> James Bessen & Eric Maskin, *Sequential Innovation, Patents and Imitation*, 16 RAND J. ECON. 237 (2009).

<sup>76</sup> Alberto Galasso, *Broad Cross-License Negotiations*, 21 J. ECON. & MGMT STRATEGY 873, 901 (2012).

<sup>77</sup> See *supra* notes 11-14 and accompanying text.

<sup>78</sup> See Ted Sichelman, *Commercializing Patents*, 62 STAN. L. REV. 341, 343 (2010) (“About half, probably more, of all patented inventions in the United States are never commercially exploited. Many of these undeveloped inventions are commercially worthless ab initio, such as the anti-eating face mask, beer bottle mini-umbrella,<sup>3</sup> and weed-cutting golf club.”).

<sup>79</sup> Michael Noel & Mark Schankerman, *Strategic Patenting and Software Innovation*, 61 J. INDUSTR. ECON. 481, 485 (2013).

<sup>80</sup> *Id.*

<sup>81</sup> Jonathan M. Barnett, *From Patent Thickets to Patent Networks: The Legal Infrastructure of the Digital Economy*, 55 JURIMETRICS 1 (2014).

<sup>82</sup> Mahdiyeh Entezarkheir, *Patent Thickets, Defensive Patenting, and Induced R&D: An Empirical Analysis of the Costs and Potential Benefits of Fragmentation in Patent Ownership*, 52 EMPIR. ECON. 599 (2017).

<sup>83</sup> Heller, *supra* note 66, at 698–701.

<sup>84</sup> *Id.* Other studies have, however, found this hypothesis unsupported. Entezarkheir, *supra* note 82, at 600.

<sup>85</sup> Noel, *supra* note 67, at 483.

The thickets arising in these markets are also shown to preclude competition<sup>86</sup> and raise consumer prices.<sup>87</sup> In fact, the mere filing of applications can deter R&D because the public information in an application “creates a specter of rights that may be larger than the actual rights.”<sup>88</sup> So as large portfolios serve the goal of inhibiting rival efforts to invent,<sup>89</sup> patent thickets might similarly lessen the fruits of innovation.<sup>90</sup>

This Article adds to the literature by investigating the strategic behaviors of individual inventors across industries with an eye towards the patent system’s ultimate goal of encouraging innovation. Prior articles—almost all of which coming from outside the legal academy—have mainly studied specific industries, theorizing how patent thickets might affect innovation without understanding the law’s relationship with power, politics, and strategy.<sup>91</sup> By taking a distinctly legal approach, we demonstrate the ways the patent system benefits entrenched inventors while less-resourced companies languish. Indeed, contrary to orthodox studies of the patent system, we explore whether the system causes firms to innovate in heterogeneous ways. To us, the exclusive rights conferred by a patent may have the primary effect of insulating those holding many patents from competition, thereby reinforcing their market power, while discouraging smaller market entrants. The ill effects are thus economic *and* social. This line of research interjects novel insights into a fractured literature that has largely ignored not only the disparate effects of strategic patenting but also how this landscape might encourage contrasting behaviors depending upon one’s patent holdings.

## II. The Deleterious Effects of Strategic Patenting on Innovation

Our belief is that the rise of strategic patenting impedes innovation. Specifically, we present evidence that the patent system reinforces the market power of the largest inventors and corporations. Although this landscape may incentivize some invention, the exclusion of upstart inventors from even entering the field renders a greater loss. The following discussion outlines our theory, presents a case study, and then establishes hypotheses which we empirically test in Part III.

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<sup>86</sup> Stephen Gillers, *The Year: 2075 the Product: Law*, 1 J. INST. STUD. LEGAL ETHICS 285, 292 (1996).

<sup>87</sup> Shapiro, *supra* note 64; Entezarkheir, *supra* note 82, at 600.

<sup>88</sup> Heller, *supra* note 66, at 698.

<sup>89</sup> Stuart Macdonald, *When Means Become Ends: Considering the Impact of Patent Strategy on Innovation*, 16 INFO. ECON. & POL’Y 136, 147 (2004).

<sup>90</sup> Entezarkheir, *supra* note 82.

<sup>91</sup> *Id.* at 698–701.

### A. *Argument and Approach*

Contrary to those who assert that *any* economic value derived from a patent bolsters the incentives to innovate, we expect strategic behaviors to cause firms to misallocate resources. By deriving value from the patenting process rather than innovation itself, this landscape encourages the creation of patent monopolies but not the dynamic benefits of them, namely scientific progress and innovation. In turn, we hypothesize (as set forth in Section II(C)) that certain firms overvalue patents, such that they prosecute applications that others would not and pay maintenance fees to avoid abandonment where others would decline to do so. The concern with overvaluing low-quality patents is that the granted monopolies and attendant deadweight losses<sup>92</sup> persist without contributing significant innovation. Further, the process encourages firms to shift attention away from the innovation process towards patenting. As inventors increasingly patent small and insignificant parts of a product as a means of erecting artificial barriers, they reallocate resources away from innovation. This enables firms to embellish their exclusive rights without creating technologies valued by society. It also incentivizes companies to favor innovating in areas that, all things equal, lend themselves to accruing hordes of patents.

This debate over the societal impact of strategic patenting continues for many reasons. Key is that not all inventors are alike. Dominant firms may exploit their patent arsenals to prevent upstart inventors from invading one's space. The hindrance to innovation affects smaller inventors who are more likely to abandon the market in light of the costs to purchase licenses, their limited cross-licensing capabilities, and inability to pay the expenses of litigation. We thus think strategic patenting has the greater effect of creating market dominance than incentivizing innovation. Perhaps the reason why industry experts seem to push for broader patent rights is that many of them advocate on behalf of the largest corporations who use the patent system to entrench their market power.<sup>93</sup>

Consider the consortiums formed by the largest patentees to bolster patent rights. For example, ostensible competitors Adobe, Amazon, Cisco, Dell, Google, Intel, and Oracle—who

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<sup>92</sup> Deadweight losses have been described as such:

A deadweight loss arises whenever goods are priced in excess of marginal cost. When price exceeds marginal cost, some consumers who value the good at more than its marginal cost, but less than its market price, will not buy it. The deadweight loss consists of the loss in consumer and producer surplus attributable to such lost sales.

Glynn S. Lunney, Jr., *Copyright's Price Discrimination Panacea*, 21 HARV. J.L. & TECH. 387, 456 (2008) (citing William W. Fisher III, *Reconstructing the Fair Use Doctrine*, 101 HARV. L. REV. 1659, 1702 (1988)).

<sup>93</sup> See *supra* note 11-14 and accompanying text.



collectively own over 115,000 patents—formed an alliance in 2017 to lobby patent policy.<sup>94</sup> The *Washington Post* found likewise that fierce lobbying efforts on behalf of the Coalition for Patent Fairness, comprised of Apple, Dell, eBay, Google, Oracle, Yahoo, produced 2011’s patent reform—the Leahy-Smith American Invents Act<sup>95</sup>—overcoming the preferences of “smaller start-ups and entrepreneurs.”<sup>96</sup> Such firms have also collaborated to assert their massive portfolios against rivals, such as Apple and Microsoft’s Rockstar Consortium.<sup>97</sup> From this evidence, one can conclude that the largest patent holders team together to craft policy despite their supposed rivalry; it should thus come as little surprise that the patent system benefits their innovation efforts more than upstart firms.<sup>98</sup>

As such, we think the decision to secure and maintain patents for the sole purpose of accruing an arsenal renders few social benefits. Although it may increase firm value, the patent system’s purpose is *not* the creation of private fortunes, but rather the promotion of societal innovation.<sup>99</sup> With this in mind, the maintenance of low-value patents is more likely to cause firms to retract from industries consumed by strategic patenting. Premised on the following case study and empirical analysis in Part III, we are confident that the deadweight loss caused by strategic patenting outweighs whatever speculative benefits may arise.

### B. *Ribbon, Metaswitch, and Patent Wars*

A recent lawsuit illustrates the complex relationship between strategic patenting and market power. Ribbon Communications (“Ribbon”) and Metaswitch compete in the market for Voice over internet Protocol (“VoIP”), which concerns the transmission of voice communications over the internet.<sup>100</sup> As VoIP supplants landline telephone systems, locales pay private companies

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<sup>94</sup> *Eight Leading Tech Companies Form High Tech Inventors Alliance to Advocate for a Balanced Patent System*, PR NEWSWIRE (Jul. 10, 2017), <https://www.prnewswire.com/news-releases/eight-leading-tech-companies-form-high-tech-inventors-alliance-to-advocate-for-a-balanced-patent-system-300485027.html>

<sup>95</sup> Pub. L. No. 112-29, 125 Stat. 284 (2011).

<sup>96</sup> Amanda Becker, *Patent reform measure ignited fierce lobbying effort*, THE WASHINGTON POST (Mar. 27, 2011), [https://www.washingtonpost.com/capital\\_business/patent-reform-measure-ignited-fierce-lobbying-effort/2011/03/25/AFzD9VkB\\_story.html?noredirect=on&utm\\_term=.b654dee97e46](https://www.washingtonpost.com/capital_business/patent-reform-measure-ignited-fierce-lobbying-effort/2011/03/25/AFzD9VkB_story.html?noredirect=on&utm_term=.b654dee97e46)

<sup>97</sup> Thom Holwerda, *Apple, Microsoft launch large patent troll attack on Android*, OS NEWS (Nov. 1, 2013) <https://www.osnews.com/story/27402/apple-microsoft-launch-large-patent-troll-attack-on-android/>

<sup>98</sup> Zach Carter, *The Spoilsmen: How Congress Corrupted Patent Reform*, WASHINGTON POST (Aug. 4, 2011), [https://www.huffingtonpost.com/2011/08/04/patent-reform-congress\\_n\\_906278.html?view=print](https://www.huffingtonpost.com/2011/08/04/patent-reform-congress_n_906278.html?view=print)

<sup>99</sup> Janet Freilich, *The Uninformed Topography of Patent Scope*, 19 STAN. TECH. L. REV. 150, 150 (2015) (noting that the “minimum amount of scope necessary to incentivize innovation.”).

<sup>100</sup> *GenBand US LLC v. Metaswitch Networks Corp.*, 861 F.3d 1378, 1379 (Fed. Cir. 2017) (reviewing the facts of the case, explaining VoIP technology).

to replace their phone lines with VoiP technology. Based on a series of transactions fueled by strategic patenting, Ribbon has cornered this market—Metaswitch being its last competitor.<sup>101</sup>

To achieve market dominance, Ribbon employed a strategy of acquiring as many patents claiming VoiP technology as possible.<sup>102</sup> Not only has Ribbon patented all parts of the process to update “legacy systems” with VoiP hardware, but it also purchased competing firms to capture their IP. Chiefly, it bought a portfolio from Nortel’s infamous bankruptcy<sup>103</sup> as well as from its acquisition of rival, Sonus.<sup>104</sup> By engaging in broad patenting buttressed by corporate mergers, Ribbon accumulated a formidable arsenal of patents which it asserts without hesitation.<sup>105</sup> The effects of Ribbon’s offensive patenting has discouraged competition on several fronts; beyond imposing infringement costs on rivals, the “aggressive” threat of litigation seems to have dissuaded firms from even entering the VoiP market.<sup>106</sup>

Most notable is Ribbon’s lawsuits against Metaswitch. According to Metaswitch, Ribbon’s litigation was preceded by efforts to acquire and “kill” the firm. When the purchase attempt failed, Ribbon sought the same result by enforcing its patent portfolio.<sup>107</sup> The first round of lawsuits claimed that Metaswitch infringed six patents that Ribbon had acquired from GenBand,<sup>108</sup>

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<sup>101</sup> Shrey Fadia, *Metaswitch Attacks Ribbon but Is Anybody Buying Ringside Seats?*, TMC Net (Dec. 3, 2018), <http://www.tmcnet.com/voip/news/articles/440508-metaswitch-attacks-ribbon-but-anybody-buying-ringside-seats.htm>

<sup>102</sup> Bart Eppenauer, *Ribbon Communication Files Two More Lawsuits against Metaswitch in Ongoing Patent Battle*, Cloud IPQ (Apr. 17, 2018), <https://cloudipq.com/2018/04/17/ribbon-communications-files-two-more-lawsuits-against-metaswitch-in-ongoing-patent-battle/> (“Ribbon’s ongoing litigation against Metaswitch is a prime example of a cloud computing company turning to its patent portfolio to fend off competition and stake out its market position.”).

<sup>103</sup> *GenBand US LLC v. Metaswitch Networks Corp.*, 861 F.3d 1378, 1379

<sup>104</sup> Carl Ford, *What Signal Does the GenBand and Sonus Merger Send to IoT*, IoT Revolution (Jun. 12, 2017), <https://www.iotevolutionworld.com/iot/articles/432701-what-signal-does-genband-sonus-merger-send-the.htm>

<sup>105</sup> *Ribbon Communications Files Two More Lawsuits against Metaswitch in Ongoing Patent Battle*, <https://cloudipq.com/2018/04/17/ribbon-communications-files-two-more-lawsuits-against-metaswitch-in-ongoing-patent-battle/> (“Ribbon touts its two decades of leadership in real-time communications and its portfolio of products built on world-class technology and intellectual property that is available for deployment in-network or in virtualized cloud environments. Ribbon’s asserted patents generally relate to telephony gateways, call routing between PSTNs and IP networks, inhibiting softswitch overload, network management system interfaces, and network traffic classification and grouping.”). See generally John R. Allison et al., *Patent Quality and Settlement Among Repeat Patent Litigants*, 99 GEO. L.J. 677 (2011) (discussing the strategies of asserting patents in court).

<sup>106</sup> *Ribbon Communications Files Two More Lawsuits against Metaswitch in Ongoing Patent Battle*, <https://cloudipq.com/2018/04/17/ribbon-communications-files-two-more-lawsuits-against-metaswitch-in-ongoing-patent-battle/>

<sup>107</sup> Edward Gately, *Metaswitch Lawsuit: Ribbon Tried to “Kill” Its Competitors* (Channel Partners Online (Nov. 19, 2018, 6:09PM), <https://www.channelpartnersonline.com/2018/11/19/metaswitch-lawsuit-ribbon-tried-to-kill-its-competitor/>; <https://www.telecomtv.com/content/metaswitch/metaswitch-files-federal-antitrust-lawsuit-against-ribbon-communications-33240/>

<sup>108</sup> *GenBand US LLC v. Metaswitch Networks Ltd.*, 211 F. Supp. 3d 858 (E.D. Tex. 2016)

resulting in a \$8.8 million award.<sup>109</sup> After Metaswitch redesigned its products to avoid infringing those patents, Ribbon initiated additional lawsuits, claiming that Metaswitch continued to employ its technology without permission.<sup>110</sup>

The problem is that Ribbon’s patenting strategies might degrade social and economic welfare. Metaswitch has pressed a novel allegation<sup>111</sup>— though not dissimilar to *AbbVie*<sup>112</sup>—of anticompetitive behavior; specifically, Ribbon’s offensive patenting strategy is predicated on initiating a maelstrom of bad faith lawsuits against rivals, which has driven nearly all competition from the VoiP market.<sup>113</sup> And due to Ribbon’s newfound market power, Metaswitch argues that consumer welfare has diminished.<sup>114</sup> The chief claim is that locales, providers, and consumers pay significantly higher prices for VoiP services as competition exits, or foregoes entering, the market.<sup>115</sup> In fact, Ribbon’s market power might insulate it from pressures to modernize rural and other poorly serviced locales, depriving these regions of vital services such as adequate 911 capabilities.<sup>116</sup> According to Martin Lund, Metaswitch’s Chief Executive Officer, “We are pursuing this case not just to protect Metaswitch, but because we believe Ribbon’s conduct is hindering customers’ ability to make fixed-line upgrades that could enhance the day-to-day lives of millions.”<sup>117</sup>

Ribbon and Metaswitch’s volley of lawsuits exemplifies the tough questions posed by strategic patenting. To Metaswitch, Ribbon’s actions eliminated nearly all other firms from the market, resulting in artificially high prices, inadequate civil services, and reduced incentives to innovate. This latter charge is critical. Not only is the VoiP market now devoid of firms able to

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<sup>109</sup> Bart Eppenauer, Ribbon Communication Files Two More Lawsuits against Metaswitch in Ongoing Patent Battle, Cloud IPQ (Apr. 17, 2018), <https://cloudipq.com/2018/04/17/ribbon-communications-files-two-more-lawsuits-against-metaswitch-in-ongoing-patent-battle/>

<sup>110</sup> Rebekah Carter, *The Battle Between Ribbon Communications and Metaswitch Continues*, UC TODAY (May 4, 2018), <https://www.uctoday.com/unified-communications/the-battle-between-ribbon-communications-and-metaswitch-continues/> (“In the suit filed on April 18<sup>th</sup>, 2018, Ribbon is seeking damages for continued infringement, claiming that the MetaSwitch redesigned products are still stepping on the toes of the company’s patents. Ribbon seeks a finding that MetaSwitch is willfully infringing on the same patents and have asked that the courts increase the royalty rate as a result.”).

<sup>111</sup> See *supra* note 21 (explaining the novelty of this type of antitrust claim).

<sup>112</sup> See *supra* notes 22 and accompanying text.

<sup>113</sup> *Metaswitch Files Federal Antitrust Lawsuit against Ribbon Communications*, TELECOMTV (Nov. 19, 2018), <http://www.ipwatchdog.com/wp-content/uploads/2018/12/Metaswitch-complaint.pdf>

<sup>114</sup> *Id.*

<sup>115</sup> *Id.*

<sup>116</sup> *Metaswitch Files Federal Antitrust Lawsuit against Ribbon Communications*, TELECOMTV (Nov. 18, 2018), <https://www.telecomtv.com/content/metaswitch/metaswitch-files-federal-antitrust-lawsuit-against-ribbon-communications-33240/>

<sup>117</sup> *Id.*

innovate products, but Ribbon’s incentives to invest in R&D have also lessened as competition exits.<sup>118</sup> Consider further that as Ribbon amassed its portfolio, little corresponding innovation has benefited many regions.<sup>119</sup> In fact, most of the litigated patents were—instead of derived from Ribbon’s R&D programs—purchased in corporate mergers for the purpose of erecting barriers to entry.<sup>120</sup> In other words, Ribbon’s use of patent rights may contravene the Constitution’s stated goal of patent law, as its portfolio is allegedly *thwarting* innovation and social improvements.

The notion, however, that Ribbon has accumulated patents to exclude competition is far from inherently wrongful. After all, the right to exclude is the primary benefit offered by the patent system.<sup>121</sup> And in light of a jury finding Metaswitch liable for infringement, it suggests that many, if not all, of Ribbon’s lawsuits might have merit. Moreover, the initial innovation of VoIP technology was likely driven by the reward of patent rights. Conclusions to be drawn from this story are thus complicated; while the rewards of patent rights were likely an impetus for prior innovation, the rise of strategic patenting in the form of private arsenals may, perversely, diminish subsequent invention.

As the preceding sections indicate, it is our theory that strategic patenting—and the corresponding thickets—lessen innovation rather than encourage it. This negative effect is especially true for smaller firms who contribute meaningfully to society’s groundbreaking innovation.<sup>122</sup> As we empirically test, strategic patenting as seen in *Ribbon* and *AbbVie* might have the primary effect of insulating market power rather than incentivizing innovation.

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<sup>118</sup> Jonathan B. Baker, *Beyond Schumpeter vs. Arrow: How Antitrust Fosters Innovation*, 74 ANTITRUST L.J. 575, 578 (2007) (explaining working of the economist Kenneth Arrow that monopolists tend to have less incentives to innovate because, without competition, they have little reason to invest money when they have little chance of capturing a greater share of the market); William Hubbard, *The Debilitating Effect of Exclusive Rights: Patents and Productive Inefficiency*, 66 FLA. L. REV. 2045, 2079 (2014).

<sup>119</sup> See *supra* notes 22 and accompanying text 113-18 (describing the unwillingness of monopolists in the field to service certain locales as they lack incentives from market forces to do so); Tim Greene, *States Want VoIP, Lack of Infrastructure*, NETWORK WORLD (May 9, 2005), <https://www.networkworld.com/article/2320770/lan-wan/states-want-voip--lack-infrastructure.html> (mentioning the lack of VoIP technology in c

<sup>120</sup> The patent involved in the litigation came from Ribbon’s predecessor, Genband. See Press Release, *U.S. Federal Court Confirms Jury Verdict against Metaswitch for Infringing Several Genband Patents*, RIBBON COMM. (Oct. 3, 2016).

<sup>121</sup> Andrew C. Michaels, *Patent Transfer and the Bundle of Rights*, 83 BROOKLYN L. REV. 933, 955 (2018).

<sup>122</sup> Roger Allen Ford, *The Patent Spiral*, 164 U. Pa. L. Rev. 827, 840 (2016); David S. Abrams & R. Polk Wagner, *Poisoning the Next Apple? The America Invents Act and Individual Inventors*, 65 Stan. L. Rev. 517, 530 (2013); Gideon Parchomovsky & R. Polk Wagner, *Patent Portfolios*, 154 U. Pa. L. Rev. 1, 74 (2005).

### C. Hypotheses

This section presents our hypotheses which we subject to empirical testing in Part III. To do so, first, we examine the pervasiveness of strategic patenting—if it occurs at all. Upon finding strong evidence of this phenomenon, the second step investigates the complex ways in which strategic patenting alters the incentives to innovate, shedding light on whether the creation of large portfolios discourages or fosters invention. Our treatment pays special attention to the power dynamics differentiating entrenched firms (those with many patents) from upstart inventors.

**Hypothesis 1A** – Firms that value patents for strategic purposes are more likely to maintain a patent regardless of its quality.

We expect firms holding large portfolios to pay maintenance fees in situations where others would not. As background, a patent is a 20-year grant of exclusivity, but a patent can lapse before reaching its full term if the owner decides against paying maintenance fees. Because rational actors should allow a valueless patent to expire while maintaining profitable ones, the decision of whether to maintain a patent requires the holder to determine if the patent's value exceeds the cost of the maintenance payment. Where technology is valuable, a firm should be willing to pay a nominal price to own it exclusively. But if the invention lacks value, the inventor can be expected to forego paying the \$1,600, \$3,600, or \$7,400 fee required to avoid abandonment (this assumption receives support from multiple studies which likewise used willingness to pay maintenance fees as a proxy for a patent's value).<sup>123</sup> So if a firm is gaining strategic benefits beyond the individual value of each patent in the portfolio, they would be more likely to pay maintenance fees where others firms (those without an arsenal) would not.<sup>124</sup> We therefore analyze whether a patentee's portfolio size influences the decision to maintain a patent regardless of its quality.

**Hypothesis 1B** – Firms that value patents for strategic purposes are more likely to expend greater costs to obtain a patent.

The choices made by owners of large portfolios during a patent's prosecution might also evidence strategic overvaluing of patent rights.<sup>125</sup> When an inventor applies for a patent, the value of the prospective patent generally diminishes as the period of time to prosecute it increases. This

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<sup>123</sup> Mark Schankerman & Ariel Pakes, *Estimates of the Value of Patent Rights in European Countries During the Post-1950 Period*, 96 *ECON. J.* 1052 (1986); Jean O. Lanjouw et al., *How to Count Patents and Value Intellectual Property: Uses of Patent Renewal and Application Data*, 46 *J. INDUS. ECON.* 405 (1998).

<sup>124</sup> See, e.g., P. Thomas, *The Effect of Technological Impact upon Patent Renewal Decisions*, 11 *J. TECH. ANALYSIS & STRATEGIC MGMT.* 181, 188 (1999).

<sup>125</sup> Prosecution is the process of filing a patent application and negotiating with a USPTO patent examiner to secure a patent. *Black's Law Dictionary* 1258 (8<sup>th</sup> ed. 2004).

is because the scope of the future patent tends to narrow due to examiner-required claim amendments.<sup>126</sup> Because a patent's value decreases in concert with claim breadth,<sup>127</sup> the applicant must determine whether the (newly narrowed) future patent's value exceeds the cost of its continued prosecution. Further, attorney fees are likely to mount during a longer process, which again diminishes the patent's economic utility. Where the costs exceed perceived future value, a rational applicant should abandon the application. In turn, we observe whether owners of large portfolios disproportionately value the possibility of obtaining a patent, all other things being equal. **Hypothesis 1B** uses application pendency—the time it takes for a patent application to be granted—to measure whether firms are relatively more accepting of costs to secure a new patent if it contributes to a larger portfolio.<sup>128</sup>

Because both **Hypotheses 1A** and **1B** observe the willingness of firms to spend additional resources to build strategic portfolios—with **1A** gauging the period of time *after* a patent is granted and **1B** concerning *before* a patent's grant—we expect to find support for both hypotheses or neither. The next query addresses whether, or how, this conduct affects innovation, shedding light on the conflicting narratives of strategic patenting behaviors.

**Hypothesis 2A** – Greater numbers of patents in a field diminish R&D expenditures in that field.

We expect for strategic patenting to lessen investment in R&D for several reasons. First, considering the costs of defending an infringement lawsuit, firms may rationally choose to limit R&D in fields saturated with patents. Second, given the necessity of cross licensing in markets where large patent portfolios prevail—as a competitor must either pay to license many patents or acquire their own portfolio to cross-license—barriers to entry are likely to discourage firms from conducting research in that market.<sup>129</sup> As such, markets where firms strategically accumulate patent portfolios are hypothesized to dissuade investment in innovation.<sup>130</sup>

**Hypothesis 2B** – Large patent holders are likely to increase R&D spending in markets saturated with patents where small patent holders are likely to diminish innovating.

Large patent holders enjoy substantial competitive advantages in markets animated by patent thickets. For instance, these firms can avoid significant licensing costs by cross licensing their arsenals with competitors who likewise maintain larger portfolios. Firms owning few patents

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<sup>126</sup> Justin Pats, *Preventing The Issuance of "Bad" Patents: How The PTO Can Supplement Its Practices and Procedures to Assure Quality*, 48 IDEA 409, 433 (2008).

<sup>127</sup> *Id.*

<sup>128</sup> Pendency is defined as the number of days between a patent's filing date and grant date. For current purposes, the "filing" date is the patents actual filing date, not its priority date.

<sup>129</sup> Cohen, *supra* note 59, at 62.

<sup>130</sup> J.H. Reichman, *Legal Hybrids Between the Patent and Copyright Paradigms*, 94 COLUM. L. REV. 2432, 2535 (1994).

must, in contrast, overcome these same barriers to entry. This disparity incentivizes entrenched firms to build patent arsenals designed to discourage smaller inventors from competing. Our expectation is thus that the patent system benefits large patent holders more than upstart inventors who—despite the potential to innovate valuable technology—lack the resources to navigate around thousands of (oftentimes extraneous) patents.

### III. Empirical Analysis

This Part empirically tests whether patent law encourages firms to strategically secure and maintain patents lacking independent value and, if so, whether this promotes or diminishes innovation. Our results refute the position that *any* value derived from patent ownership encourages firms to invent in R&D. We find, first, patentees are more likely to pay maintenance fees or prosecute an application—regardless of the patent’s quality—if it bolsters the patentee’s arsenal. Our second analysis shows that, as the total patents in a market grows, firms invest less in innovation. This disincentive is especially powerful for smaller inventors (those with fewer patents) who generate much of society’s groundbreaking innovation,<sup>131</sup> whereas strategic patenting can help to insulate the market power of industry stalwarts. We conclude that the patent system could produce more innovation if it encouraged firms to allow bad patents to lapse. This Part outlines our empirical methods, reviews summary statistics, and then presents our findings and analysis.

#### A. *The Data Collected*

To create our dataset, we collected information for patents numbered 5,274,846 (first 1994 grant) to 6,671,883 (last 2003 grant), producing a population of 1,386,198 patents.<sup>132</sup> Our unit of analysis is thus the patent, meaning that each patent granted from 1994-2003 was observed. We analyzed a ten-year period to minimize the influence of extrinsic factors (e.g., economic and

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<sup>131</sup> Roger Allen Ford, *The Patent Spiral*, 164 U. Pa. L. Rev. 827, 840 (2016); David S. Abrams & R. Polk Wagner, *Poisoning the Next Apple? The America Invents Act and Individual Inventors*, 65 Stan. L. Rev. 517, 530 (2013); Gideon Parchomovsky & R. Polk Wagner, *Patent Portfolios*, 154 U. Pa. L. Rev. 1, 74 (2005).

<sup>132</sup> This number was out of 1,397,037 predicted by the first and last patent numbers (>99.2%). This finding is unsurprising, given that not all numbers are actually assigned. USPTO, *TAF Report: Issue Dates and Patent Numbers Since 1836* (Apr. 2002), <https://www.uspto.gov/web/offices/ac/ido/oeip/taf/issudate.pdf> (“Note that some numbers within a series may be unused. Therefore, the number of patents granted during a year cannot be determined by simply subtracting the number of the first patent issued in one year from the number of the first patent issued in the next year”). For a list of the first utility patent number issued in a given year, see USPTO, *Table of Issue Years and Patent Numbers, for Selected Document Types Issued Since 1836* (2016), <https://www.uspto.gov/web/offices/ac/ido/oeip/taf/issuyear.htm>.

industry-specific concerns), which is an improvement over prior studies.<sup>133</sup> Our data are derived from 1) the United States Patent and Trademark Office’s (“USPTO”) PatentsView database, which provides information on assignees, claims, inventors, citations, and technological class<sup>134</sup> as well as 2) the Patent Examination Research Dataset (PatEx), which contains data on a patent’s application number, filing date, priority information, and number of inventors.<sup>135</sup> We additionally identified whether each patentee qualifies as a *Small Entity* (firms falling under an employee threshold<sup>136</sup> to control for effects associated with firm size<sup>137</sup>) using information hosted by Google’s Bigquery SQL platform.<sup>138</sup> We observed only “ordinary” utility patents to the exclusion of design patents, re-issues, and plant patents.<sup>139</sup>

## B. Methods of Analysis

Our empirical methods explore whether the incentives to obtain as well as maintain a patent—especially low-value ones—frustrate innovation especially on behalf of smaller, upstart inventors. To test **Hypothesis 1A**, we performed a survival analysis (also known as a hazard analysis) designed to uncover the factors influencing whether a firm allows a patent to lapse. A survival analysis estimates an event’s “hazard rate,” which is the odds that certain factors predict an event’s failure as a binary choice (e.g., sustained peace after war or war recurrence) measured by how quickly that failure occurs (e.g., war recurrence in a week or recurrence in a year).<sup>140</sup> A

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<sup>133</sup> Kimberly A. Moore, *Worthless Patents*, 20 Berkeley Tech. L.J. 1521, 1529 (2005) (analyzing maintenance fee payment for patents issued in a one year).

<sup>134</sup> Brian J. Love et al., *Determinants of Patent Quality: Evidence from Inter Partes Review Proceedings*, UNIV. COLO. L. REV. (forthcoming Feb. 13, 2018), [https://papers.ssrn.com/sol3/papers.cfm?abstract\\_id=3119871](https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3119871); (“PatentsView Data is a database that longitudinally links inventors, their organizations, locations, and overall patenting activity. The dataset uses data derived from USPTO bulk data files.”); “PatentsView” by the USPTO, US Department of Agriculture (USDA), the Center for the Science of Science and Innovation Policy, New York University, the University of California at Berkeley, Twin Arch Technologies, and Periscopic, used under CC BY 4.0, <https://bigquery.cloud.google.com/dataset/patents-public-data:patentsview>.

<sup>135</sup> See Stuart, Graham et al., *The USPTO Patent Examination Research Dataset: A Window on the Process of Patent Examination*, Working Paper No. 2015-4 (Nov. 2015), <http://www.uspto.gov/economics> (describing the PatEx database). This dataset is available via Google’s BigQuery SQL platform. Dataset Details: patents-public-data:uspto\_oce\_pair, [https://bigquery.cloud.google.com/dataset/patents-public-data:uspto\\_oce\\_pair?tab=schema](https://bigquery.cloud.google.com/dataset/patents-public-data:uspto_oce_pair?tab=schema).

<sup>136</sup> See *Ulead Sys., Inc. v. Lex Computer & Mgmt. Corp.*, 351 F.3d 1139 (Fed. Cir. 2003) (citing 37 C.F.R. § 1.9(d); 35 U.S.C. § 41(h) (2000)).

<sup>137</sup> Patrick Thomas, *The effect of technological impact upon patent renewal decisions*, 11 J. TECHNOLOGY ANALYSIS & STRATEGIC MANAGEMENT 181, 189 (1999).

<sup>138</sup> *Id.*; Ian Wetherbee, *Google Patents Public Datasets: Connecting Public, Paid, and Private Patent Data*, GOOGLE CLOUD BIG DATA & MACHINE LEARNING BLOG (Oct. 31, 2017), <https://cloud.google.com/blog/big-data/2017/10/google-patents-public-datasets-connecting-public-paid-and-private-patent-data>.

<sup>139</sup> Jensen et al., *Gender Differences in Obtaining and Maintaining Patent Rights*, 36 NATURE BIOTECH. 2 (2018).

<sup>140</sup> This method was developed by the health care industry to determine whether certain diseases or treatments are more or less hazardous to one’s health. It does so by not only determining whether the event is likely to cause death but also how rapidly death can be expected—e.g., an event that causes death faster than another event is thus considered more hazardous.



survival analysis thus uses two dependent variables: the first is a dummy variable reflecting whether or not the “failure” occurred and the second is a time-variable measuring the amount of time elapsed until that failure took place. Here, our hazard analysis identifies which factors are likely to cause a patent to lapse in terms of likelihood and expediency. All things being equal, a factor associated with patents lapsing in four years rather than twelve years is considered more hazardous. So if firms maintain patents belonging to arsenals at higher rates after controlling for factors measuring a patent’s quality (as detailed in the next section), this would offer strong evidence that firms ascribe significant value to patents as strategic entities—regardless of whether the patent is protecting a commercially valuable invention. We used a Fixed Effects Analysis to test **Hypothesis 1B** concerning whether firms holding large patent portfolios are more likely to spend greater costs on pursuing a patent, controlling for its quality.<sup>141</sup> The benefit of using a fixed effects regression is that it controls for deviations among the various markets; by essentially isolating the effects of industry differences, the treatment investigates the degree to which this phenomenon prevails regardless of sector. Conversely, we suspect that a firm that values a patent simply for its exclusionary benefits—rather than for strategic purposes—is more likely to abandon the patenting process if mounting costs appear to be greater than the speculative benefits.

In the last step, our analysis tested **Hypothesis 2A**, which posited that R&D expenditures negatively relate to the number of patents existing within that field. For this point, we performed a fixed effects regression to explain whether the number of patents in an industry are likely to cause firms in that field to increase or lessen R&D spending. This type of expenditure is key because the patent system is meant to encourage actors to invest in the activities leading to innovation.<sup>142</sup> We use these same methods to determine whether the number of patents in a certain field (*Patents in the Field*, which is described in the next section) has a greater, deleterious effect on smaller inventors (those with few patents), or even whether *Patents in the Field* promotes activity from firms with many patents—as hypothesized in **2B**.

### C. *The Variables*

For the first analysis (the survival analysis testing the relationship between one’s portfolio size and willingness to pay maintenance fees), we created dependent variables measuring not only whether a patent lapsed, but also in how many years it lapsed. To do so, we collected data on maintenance fee payments for the observed patents. Because a failure to pay a patent’s maintenance fee causes that patent to expire before reaching its twenty-year term,<sup>143</sup> we catalogued

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<sup>141</sup> A survival analysis is inappropriate for this task because the dependent variable is no longer a binary outcome which is essential for a survival analysis. Here, the dependent concerns the amount of time taken to prosecute the patent.

<sup>142</sup> Benjamin N. Roin, *Unpatentable Drugs and the Standards of Patentability*, 87 TEX. L. REV. 503, 508 (2009).

<sup>143</sup> *Burandt v. Dudas*, 496 F. Supp. 2d 643 (E.D. Va. 2007).

at which year each patent lapsed—whether at the 4<sup>th</sup>, 8<sup>th</sup>, 12<sup>th</sup>, or 20<sup>th</sup> year.<sup>144</sup> Expiration data were obtained from the USPTO’s Patent Maintenance Fee Events database<sup>145</sup> and uploaded onto a SQL server. This generated two dependent variables (as previously discussed is required in a hazard analysis): whether the patent *Lapsed* (1: lapsed, 0: did not lapse) and its *Survival* (meaning how long until it lapsed). We also used this dataset to construct the dependent variable of *Pendency*, referring to the amount of time from the patent’s application until its grant (*i.e.*, the date of grant minus the application date). As for the key independent variable, we created *Portfolio Size* reflecting each firm’s portfolio size, which was calculated in a multistep process. We ascertained patent ownership from publicly available assignments filed with the USPTO,<sup>146</sup> accessible on the PatentsView database.<sup>147</sup> To resolve ambiguities found in the names of patentees (e.g., misspellings, varying or omitted business type identifiers, abbreviations, etc.), we reviewed the assignees’ names by hand.<sup>148</sup> Our survival analysis is thus designed to measure the manner in which a firm’s *Portfolio Size* leads to maintenance fee payment, controlling for each firm’s resources and patent quality (which we describe next).

As for our control variables, we first accounted for variations in technology areas.<sup>149</sup> From the PatentsView database, we collected data for each of the nine areas: Computers, Biology,

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<sup>144</sup> 35 U.S.C. § 41(b) (maintenance fees are due after 3.5, 7.5, and 11.5 years).

<sup>145</sup> USPTO, *Patent Maintenance Fee Events* (Sep 1, 1981-present) (patent maintenance fee products), <https://developer.uspto.gov/product/patent-maintenance-fee-events-and-description-files>.

<sup>146</sup> Assignment data was pulled from “USPTO OCE Patent Assignment Data” which is hosted in a Google Bigquery SQL database. Dataset Details: [patents-public-data:uspto\\_oce\\_assignment](https://bigquery.cloud.google.com/dataset/patents-public-data:uspto_oce_assignment), [https://bigquery.cloud.google.com/dataset/patents-public-data:uspto\\_oce\\_assignment](https://bigquery.cloud.google.com/dataset/patents-public-data:uspto_oce_assignment); Alan C. Marco et al., *The USPTO Patent Assignment Dataset: Descriptions and Analysis* (July 27, 2015), [https://www.uspto.gov/sites/default/files/documents/USPTO\\_Patents\\_Assignment\\_Dataset\\_WP.pdf](https://www.uspto.gov/sites/default/files/documents/USPTO_Patents_Assignment_Dataset_WP.pdf). This database is derived from USPTO’s Patent Assignment Dataset. USPTO, Patent Assignment Dataset, <https://www.uspto.gov/learning-and-resources/electronic-data-products/patent-assignment-dataset> (“The 2017 update to the Patent Assignment Dataset contains detailed information on 8.0 million patent assignments and other transactions recorded at the USPTO since 1970 and involving roughly 13.1 million patents and patent applications”).

<sup>147</sup> See *Why Corp. v. Super Ironer Corp.*, 128 F.2d 539, 609 (6th Cir. 1942). For purposes of this research, filing other than patent assignments (e.g., security interests, licenses, etc.) were not considered, as they are not relevant. Since a single assignment may list multiple assignees (creating multiple owners) and patents could be assigned multiple times, we determined the portfolio size for each patent owner in the year it paid a maintenance fee by identifying all valid patents held by one of the identified assignees. A patent was deemed still valid if it hadn’t been abandoned for failure to pay maintenance fees and was within 20 years of its effective filing date, which oversimplifies that calculus for some patents but that effect is expected to be negligible. See *Brigham & Women’s Hosp. Inc. v. Teva Pharms. USA, Inc.*, 761 F. Supp. 2d 210 (D. Del. 2011) (citing 35 U.S.C. § 154).

<sup>148</sup> The review took a narrow view of what constituted the same company (to the exclusion of many subsidiaries being included with their parent companies, with firms with different corporate designations coded differently. Effects of mergers were assumed negligible.

<sup>149</sup> We identified the technology area of each application by its art unit (technology-specific groups of patent examiners). Indeed, the USPTO assigns applications to art units for examination, each unit of which is housed in a broader technology center (e.g., art units in the 1720s pertain to batteries, etc., while technology center 1700 is for

Chemistry, Mechanical Engineering, Semiconductors, Communications, Textiles, Transportation, and E-Commerce,<sup>150</sup> which formed the basis of our fixed effects analyses. We also controlled for a patent's quality because patent holders are more likely to maintain a commercially successful patent. To do so, our treatment included variables that Moore found important in *Worthless Patents*,<sup>151</sup> such as number of applications to which a patent claimed *Priority*, the *Number of Inventors*, and the *Number of Claims*.<sup>152</sup> Another proxy of patent quality in prior studies<sup>153</sup> is

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“Chemical and Materials Engineering.”) These units have, however, been the subject of several reassignments during the term of this study; these changes have been accounted for. In the middle of the ten-year period under study (1997), several technology centers were consolidated (2200, 3100 and 3500 into 3600 (“Transportation”); 1200, 1800 and 2900 into 1600 (“Biology”— This group of patents was also partially allocated to new 2900, but these patents are ignored as those patents are design patents, which are excluded from the study); 1100, 1300 and 1500 into 1700 (“Chemistry”); 3200, 3300 and 3400 into 3700 (“Mechanical Engineering”); 2100 and 2500 into 2800 (“Semiconductors”)) in 1997-98. USPTO, *Notice of Consolidation and Move of the Patent Examining Corps*, <https://www.uspto.gov/news/og/1997/week45/patmove.htm>. Each of these new centers are coded for via dummy variables in the dataset. Centers 2300, 2400 and 2600 were merged into 2700 in the late 1990s, but 2700 was subsequently broken into 2100 and 2600 in 2000. Wynn Coggins, *Technology, Center 2700 Splits to Accommodate Growth in Computer-Related Applications*, USPTO TODAY 12 (Nov. 2000). The “new” center 2100 (created in 2000 and still existing) clearly includes old center 2300, and thus, old 2300 patents are coded as “new” 2100 (“Computers”). *Id.* Any patent whose application filed post 1999 which was allocated to center 2100 is treated as “new” 2100 and all others are allocated to center 2800 (which 2100 was allocated to in 1997-98). Patents from the original technology 2600 clearly falls into the new 2600 (“Communications”), and thus, are coded as such. Center 2400 (“Textiles”) does not clearly fall into any category, and accordingly, is independently coded. There is a new center 2400 created in 2009. Sean Tu, *Luck/Unluck of the Draw: An Empirical Study of Examiner Allowance Rates*, 2012 STAN. TECH. L. REV. 10, 14 (2012). That is, however, outside the scope of the current dataset, and thus, is unimportant. Likewise, there is no way to break the 2700 unit's patents (“E-Commerce”) into groups, so they are coded independently.

<sup>150</sup> While technology centers controlled for area of technology, a more granular division was necessary to explore the relationship between R&D expenditures and patents in the field. For this, the over 400 main classes from the U.S. Patent Classification (USPC) system were employed. Patents were thus coded for their USPC main class with information obtained *See generally* Saurabh Vishnubhakat, *The Field of Invention*, 45 HOFSTRA L. REV. 899, 904 (2017). These headings are generalizations of the subject matter contained therein. Full information is available at: Patent Technology Centers Management, <https://www.uspto.gov/patent/contact-patents/patent-technology-centers-management>.

<sup>151</sup> Kimberly A. Moore, *Worthless Patents*, 20 BERKELEY TECH. L.J. 1521, 1521 (2005).

<sup>152</sup> *Id.* at 1537-39. This is because during a patent's prosecution, examiners review prior art to determine whether the invention is distinct from those previously disclosed. Audra Dial & Betsy Neal, *Proving Patent Damages Is Getting Harder, but Establishing Patent Invalidity May Be Getting Easier-How I4i, L.P. v. Microsoft Corp. May Change the Landscape of Patent Litigation*, 12 N.C.J.L. & TECH. ON. 119, 127 n.38 (2011). Once an examiner determines that the new invention is different from known technology, the old patent is identified (cited) on the cover of the new one. MANUAL OF PATENT EXAMINING PROCEDURE § 609.06 (9th ed. 2018). (“The number of inventors, time in prosecution, and number of related applications also continue to play a significant role in patent maintenance.” It is notable that Moore recognizes that time in prosecution will directly relate to number of related applications. Time in prosecution was not controlled for here due to collinearity concerns).

<sup>153</sup> P. Thomas, *The Effect of Technological Impact upon Patent Renewal Decisions*, 11 J. TECH. ANALYSIS & STRATEGIC MGMT. 181, 184-187 (1999).

*Citations* to the patent<sup>154</sup> for which we controlled.<sup>155</sup> Additionally, since the Patent Act entitles *Small Entities* (fewer than 500 employees<sup>156</sup>) to pay reduced fees,<sup>157</sup> we identified small entities so as to control for effects associated with the patentee’s size (and by proxy, their resources).<sup>158</sup> We also coded for economic fluctuations (*Change in GDP*) and the size of a company’s annual assets holdings. This latter variable was key in controlling for each company’s resources; we expect to conclude that large firms collect arsenals, *not* because they have the resources to do so, but for strategic purposes.

These same variables are used to test Hypothesis 1B, which is the fixed effects analysis measuring the relationship between *Pendency* and *Portfolio Size*. This treatment determines whether each firm’s *Portfolio Size* influences that firm’s decision to undergo a more expensive application process.

For the final analyses testing the effects of strategic patenting on R&D Spending (Hypotheses **2A** and **2B**), the dependent variable is *R&D Spending* which we derived from CompuStat data. We test two key independent variables. The first, *Patents in Force*, measures the number of patents within a certain industry—as we hypothesize that the large number of patents in an area diminishes innovation—which we created from USPC main class data. Because we hypothesize that this dynamic primarily harms smaller inventors, we include the variable *Portfolio Size*.

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<sup>154</sup> Blind, *supra* note 56, at 428. Hall, Jaffee, and Trajtenberg found that—regarding US patents—firms whose patents were cited above the median of citations per patent exhibited a “very significant increase in market value” and this increase was particularly large for firms with average citations above 20 per patent. B.H. Hall et al., *Market Value and Patent Citations*, 36 RAND J. ECON. 16, 30 (2005).

<sup>155</sup> Moore, *supra* note 151, at 1537. The paper implicitly assumes that patent owners are aware of a patent’s value (or lack thereof) at the time of fee payment, though the citation metrics to support this valuation may not be apparent until some later time. Any citation made before August 2017 was included in this database, despite the fact that some citations may not have been made at the time a patentee decided whether to pay a maintenance fee.

<sup>156</sup> *Christy, Inc. v. United States*, 2019 U.S. Claims LEXIS 29, \*12 n. 6 (Fed. Cl. 2019).

<sup>157</sup> See *Ulead Sys., Inc. v. Lex Comput. & Mgmt. Corp.*, 351 F.3d 1139 (Fed. Cir. 2003) (citing 37 C.F.R. § 1.9(d); 35 U.S.C. § 41(h) (2000)).

<sup>158</sup> Research finds that these parties are less likely to pay maintenance fees, despite the reduction in price they pay. Thomas, *supra* note 126, at 189.

#### D. Descriptive Statistics

Of the 1,386,198 patents in our dataset,<sup>159</sup> past research predicts that approximately 50% are likely to lapse early.<sup>160</sup> Confirming this expectation, 51.79% of our studied patents expired before reaching their full terms. The rate of early expiration was greater among small entities, with 70.96% of the 336,977 small entity patents lapsing. The average early expiration occurred in 8.33 years, which mirrors an earlier study (8.18 years).<sup>161</sup> We set forth the rate of expiration by inventor type and maintenance fee period in Table 1. Failure rates climbed from 14.12% at the fourth year to 27.66% in year twelve; small and non-small patentees followed a similar trend but with small entity patents expiring at a higher rate.

**Table 1 – Patents Expired by Maintenance Fee Period**

Table 2 displays the rate of expiration by technology area,<sup>162</sup> excluding patents where this

	<b>Patents Up for Maintenance Payment</b>	<b>Patent Expirations in This Period</b>	<b>Percent of All Patents Expired this Period</b>
<b>4 Year - All Patents</b>	<b>1,386,198</b>	<b>195,701</b>	<b>14.12%</b>
4 Year - Small Entity	336,977	87,757	26.04%
4 Year - Non-Small Entity	1,049,221	107,944	10.29%
<b>8 Year - All Patents</b>	<b>1,190,497</b>	<b>266,013</b>	<b>22.34%</b>
8 Year - Small Entity	249,220	86,583	34.74%
8 Year - Non-Small Entity	941,277	179,430	19.06%
<b>12 Year - All Patents</b>	<b>924,484</b>	<b>255,667</b>	<b>27.66%</b>
12 Year - Small Entity	162,637	64,773	39.83%
12 Year - Non-Small Entity	761,847	190,894	25.06%
<b>All Years - All Patents</b>	<b>1,386,198</b>	<b>717,381</b>	<b>51.75%</b>
All Years - Small Entity	336,977	239,113	70.96%
All Years - Non-Small Entity	1,049,221	478,268	45.58%

information was unavailable (1,376,081 of 1,386,198 (99.27%) identified).

<sup>159</sup> Looking only to patents that included technology center information in PatentView, 1,066,799 were assigned (excluding security interests and licenses) and 309,282 were not.

<sup>160</sup> Moore, *supra* note 151, at 1526; Mark A. Lemley, *Rational Ignorance at the Patent Office*, 95 NW. U. L. REV. 1495, 1504 (2001); Lucas S. Osborn et. al., *A Case for Weakening Patent Rights*, 89 ST. JOHN'S L. REV. 1185, 1246 (2015).

<sup>161</sup> Saurabh Vishnubhakat, *Expired Patents*, 64 CATH. U. L. REV. 419, 432 (2015).

<sup>162</sup> For a full discussion of how patents were allocated into these fields of technology and the full breadth of each field, see *supra* notes 149.

**Table 2 – Patents Expired by Maintenance Fee Period by Technology**

	<b>Patents Issued</b>	<b>Expired Early</b>	<b>Expired in Year 4</b>	<b>Expired in Year 8</b>	<b>Expired in Year 12</b>
<b>Biology</b>	135,871	56.65%	14.09%	21.23%	21.29%
<b>Chemistry</b>	245,686	52.89%	13.66%	20.12%	19.08%
<b>Computers</b>	35,363	39.56%	7.98%	15.39%	16.14%
<b>Communications</b>	75,777	42.80%	8.92%	15.90%	17.95%
<b>Textiles</b>	14,965	56.67%	20.00%	21.00%	15.61%
<b>E-Commerce</b>	85,129	38.17%	9.01%	13.64%	15.52%
<b>Semiconductors</b>	325,058	45.87%	10.18%	17.06%	18.61%
<b>Transportation</b>	203,121	60.44%	20.07%	22.32%	18.00%
<b>Mechanical Engineering</b>	262,665	57.13%	18.43%	20.56%	18.09%

### *E. Empirical Results*

First, our empirical results provide strong evidence (almost all of our variable were highly statistically significant) that firms obtain and maintain patents—regardless of quality—as a means of generating large patent arsenals. Second, although the commodification of patent rights could increase the incentives to innovate, as some suggest, we find the opposite. Our research demonstrates that these deleterious effects are primarily suffered by upstart inventors, while larger entrenched firms (those with more patents) flourish in this environment, generating powerful economic and social consequences. In essence, strategic patenting embellishes the market power of industry stalwarts while preventing innovation and competition from upstart firms, generating a net loss of innovation.

The first analysis (Models 1 and 2 in Table 3) shows that as a firm’s portfolio size increases, so does the likelihood that the firm will maintain its patents—even the low-value ones. To reach this conclusion, the variable *Portfolio Size* is key. By being negative and statistically significant, it supports **Hypothesis 1A** that firms owning greater numbers of patents are less likely to allow their patents to lapse regardless of each patent’s quality (as we controlled for patent quality using several variables detailed above). Our second analysis, which tested **Hypothesis 1B**, found results similar to the first analysis (our second analysis is displayed in Models 5 and 6 in Table 5 in the Appendix). Using pendency data, the models indicate that firms with large holdings are more willing to incur greater costs to navigate a lengthy application process whereas smaller holders abandon similar applications when the costs mount. This again suggests that patentees with larger portfolios ascribe strategic value to their patents beyond protecting original methods and inventions. So to summarize our initial analysis, we find strong evidence of firms engaging in strategic patenting activities.

In important part, to avoid concerns that large firms pay maintenance fees because they simply have the resources to do so, we empirically differentiated patent holdings from resources. When controlling for the assets owned by a firm, we found that portfolio size promotes payment of maintenance fees *independent* of the firm’s wealth. Bolstering this finding, we then included the variable *Small Entity* in an additional model; the results reinforce our conclusion that firms pay maintenance fees to build arsenals regardless of their resources and quality of patents. The driving factor behind maintaining low quality patents is thus a strategic plan to exclude competition (the models are found in Table 7 in the appendix. A control variable was added to account for multicollinearity whereby the variables were multiplied together to control for their interactive relationship).

The greater question concerns how strategic patenting affects innovation, especially considering the contentious debate surrounding the issue. In Models 3 and 4 found in Table 4, we find that as the number of patents in an area increases, firms in that industry are likely to *decrease* their R&D spending. In Model 3, the key variable is *Patents in Force* which is negative and significant; as the number of patents in a patentee’s industry mount, the firm is likely to lessen R&D spending. The corollary is that firms are more likely to spend on R&D in industries characterized by relatively fewer patents. This entails strong evidence in support of **Hypothesis 2A**: *R&D expenditures decrease as Patents in the Field increase*.

Next in Model 3, the variable for the size of a firm’s patent portfolio (*Portfolio Size*) was found to be positive and statistically significant, meaning that firms with large patent portfolios invest heavily in R&D even when their market is saturated with patents. Considering that the presence of a patent thicket generally reduces R&D spending, we show that larger (owning more patents) firms are less affected by the presence of patent thickets and large portfolios. In fact, large firms are shown to *increase* their R&D spending in industries known for patent thickets, suggesting that small and medium sized businesses are the firms dissuaded by strategic patenting. We thus support **Hypothesis 2B**.

We found the same results using a second type of treatment (Model 6 in Table 6 in the Appendix). Instead of studying a firm’s *Portfolio Size*, we added a variable for *Small Entity*, which is a dummy variable capturing essentially the size of the patent owner (i.e., number of employees). Although our research emphasized *Portfolio Size* because it is the more nuanced variable, we felt it important to confirm our results as best as possible. And like companies with fewer holdings, firms that the USPTO has demarked as a small entity are less likely to invest in R&D within fields saturated with patents, providing additional support for our findings.

Although in Table 3 we chose to report Biology and Chemistry variables controlling for industry, we ran unreported models. The models remained consistent despite the industry.

**Table 3. Survival Analysis**

	<u>Model 1</u>	<u>Model 2</u>
<i>Likelihood of Patent Lapsing</i>		
Numb. of Claims	<b>-.0088795***</b>	<b>-.008834***</b>

	(.0001116)	(.0001097)
Numb. of Parents	<b>-.0102061***</b>	<b>-.0033935***</b>
	(.0013154)	(.0012613)
Numb. of Inventors	<b>-.0545165***</b>	<b>-.0499104***</b>
	(.0008131)	(.0007688)
Numb. of Patents Citing	<b>-.0075038***</b>	<b>-.0076541***</b>
	(.0000532)	(.0000523)
Biology Dummy	<b>.1003706***</b>	
	(.004108)	
Chemicals Dummy	<b>.0076851**</b>	
	(.003195)	
Portfolio Size	<b>-0.0000923***</b>	<b>-0.00000982***</b>
	(000000241)	(.000000237)
GDP Control	<b>.0042224***</b>	<b>.0042412***</b>
	(.0009388)	(.000929)

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Prob > chi2	<b>0.0000***</b>	<b>0.0000***</b>
No. of Subjects	1347585	1391207

\*p<0.10, \*\*p<0.05, \*\*\*p<0.01

**Table 4. Fixed Effects**

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	<u>Model</u> 3	<u>Model</u> 4
<i>R&amp;D Spending</i>		
Portfolio Size	<b>.1533684***</b>	<b>.1545539***</b>
	(.0004109)	(.0004062)
Patents in Force	<b>-.0027783***</b>	<b>-.0027115***</b>
	(.0002785)	(.0002789)
GDP Control	<b>37.9011***</b>	<b>41.3919***</b>
	(2.839433)	(2.836229)
Constant	<b>595.7376***</b>	<b>554.2108***</b>
	(12.6622)	<b>(10.62409)</b>
Numb. of Claims	<b>-4.895427***</b>	
	(.2552155)	
Numb. of Parents	<b>-17.01457***</b>	
	(3.858496)	
Numb. of Inventors	<b>30.72751***</b>	
	(2.032198)	
Numb. of Patents Citing	<b>-.2600559***</b>	
	(.0769965)	

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Prob > F	<b>0.0000***</b>	<b>0.0000***</b>
R-Squared	0.5235	0.5216
No. of Observations	146474	146485

\*p<0.10, \*\*p<0.05, \*\*\*p<0.01

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## F. Analyses and Conclusions

These results suggest that the incentive to maintain low-quality patents in a large portfolio harms innovation. Contrary to the theory advanced by certain scholars and industry proponents, any value that can be extracted from a patent does not necessarily advance innovation. Instead, the manner in which firms collect patents as parts of an arsenal—and the way firms strategically use those patents to frustrate downstream inventors—raises the costs of innovation and thereby diminishes R&D. The evidence indicates that the patent system could generate more innovation if its structure incentivized firms to allow their worthless patents to expire.

An interesting finding in the second model is that, whereas relatively greater numbers of patents in a field (i.e., *Patents in Force*) diminishes R&D spending (i.e., patent thickets discourage R&D Spending in the aggregate), the greater number of patents owned by a patentee (i.e., *Portfolio Size*) increases that patentee's R&D spending (i.e., large patent holders increase their R&D efforts within a patent thicket). It demonstrates a bifurcated system of haves and have-nots. The dominant firms possessing large portfolios continue to invest in R&D regardless of whether the market is saturated with patents—or, in fact, they invest more resources. But when accounting for those firms, we find that patent thickets seem only to be discouraging small and upstart companies from investing R&D dollars in those areas. This is, in fact, the *intended effect* of large arsenals; as dominant players use their patent holdings to erect barriers to entry, it prevents competition from upstart companies. The accumulation of large patent portfolios can, in essence, enable the dominant firms to maintain their market power. Especially since many observers credit smaller, upstart firms with producing groundbreaking innovations,<sup>163</sup> dominant firms seem to be using large portfolios to insulate their market power from some of the most innovative firms.

Another noteworthy result is that the acts of patenting and innovating can be distinctly different. Since it is common for inventors to pursue patent rights for their inventions, there is a common assumption that the act of patenting is essentially the same as innovating. For instance, many studies control for innovation by using patents as a proxy.<sup>164</sup> We demonstrate that R&D investment, and thus innovation, can actually *lessen* in the shadow of mounting patent grants. In other words, incremental increases of patenting may actually reflect diminished innovation. According to our research firms pursue patents for their ability to block competition even though the innovation embodied in a patent might have almost no commercial value. This unmooring of innovation from patenting is troublesome. Because the granting of exclusive rights creates deadweight loss, the law should, but does not, encourage firms to apply for a patent only when the invention is worth protecting.

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<sup>163</sup> Roger Allen Ford, *The Patent Spiral*, 164 U. Pa. L. Rev. 827, 840 (2016); David S. Abrams & R. Polk Wagner, *Poisoning the Next Apple? The America Invents Act and Individual Inventors*, 65 Stan. L. Rev. 517, 530 (2013); Gideon Parchomovsky & R. Polk Wagner, *Patent Portfolios*, 154 U. Pa. L. Rev. 1, 74 (2005).

<sup>164</sup> See, e.g., Jeffrey L. Furman et al., *The Determinants of National Innovative Capacity*, 31 RES. POL'Y 899, 909 (2002).

## IV. Applications

Our findings inform discussions about whether any value that can be derived from a patent serves the goals of the Constitution’s IP Clause (i.e., encouraging innovation). The following subsection addresses this issue, concluding with policy suggestions to improve the patent system.

### A. *Not All Patents Are Good for Innovation*

Significant debate exists among both practitioners and academics regarding whether the existence of *all* patents is beneficial for technological (and thus economic) growth. For instance, former FTC Commission, Maureen K. Ohlhausen, unequivocally asserts that “[more] patents materially spur [more] innovation” and lead to “demonstrably superior innovation in IP-intensive industries.”<sup>165</sup> This sentiment echoes the early work of Simone A. Rose, which asserted that “technological innovation and economic growth” is undercut when patent filings diminish.<sup>166</sup> Absolute positions of this nature are ultimately summed up in the policy stance that “more patents

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<sup>165</sup> Maureen K. Ohlhausen, *Patent Rights in a Climate of Intellectual Property Rights Skepticism*, 30 HARV. J. LAW & TEC 103, 126 (2016) (“While the evidence is subject to competing interpretations -- and even statistically significant correlations between patent counts and R&D are susceptible to competing interpretations [Link to the text of the note](#) -- it is certainly consistent with the proposition that patents materially spur innovation.” (citation omitted); *see also* Reiko Watase, Note, *The American Inventors Protection Act Of 1999: An Analysis Of The New Eighteen-Month Publication Provision*, 20 CARDOZO ARTS & ENT LJ 649, 681 (“Perhaps one approach to resolve this conflict is to support the views of those who are awarded more patents, those endeavoring to serve the public interest by furthering technological and economic growth.”); Jonathan M. Barnett, *From Patent Thickets to Patent Networks: The Legal Infrastructure of the Digital Economy*, 55 JURIMETRICS 1, 2 (2014) (“There is little indication that the significant growth in patent issuance and litigation since the early 1980s has adversely affected R&D investment or product output or pricing in the consumer electronics markets.” (citations omitted)).

<sup>166</sup> Simone A. Rose, *Patent "Monopolyphobia": A Means of Extinguishing the Fountainhead?*, 49 CASE W. RES. 509, 514 & 527 (1999). Rose would ultimately reverse her stance on the issue. *See* Simone A. Rose, *Further Reflections on Extinguishing the Fountainhead of Knowledge: A Call to Transition to the "Innovation Policy" Narrative in Patent Law*, 66 SMU L. Rev. 609, 612 (2013) (questioning the conclusions of her earlier work)

equals more innovation.”<sup>167</sup> While some empirical work supports this position,<sup>168</sup> another body of literature stands in disagreement.<sup>169</sup>

Our findings fill a void in the literature by adding a substantial empirical underpinning to these concerns. Patents—a tool meant to encourage innovation—are actually discouraging research when large portfolios are held in a discrete field. This is exasperated by the self-reinforcing nature of the problem, given that firms respond to patent thickets by propelling their own patenting activities, which strengthens the thicket, and so on.<sup>170</sup>

These determinations are of particular concern given the firm size-specific nature of our conclusions. Firms with substantial patent holdings are unaffected by an upsurge in patents in their field; they continue to spend on R&D. In contrast, those with relatively fewer patents reduce research expenditures in the face of substantial patent holdings. This divergent response to patent thickets initially deprives the market of new products, net innovation, and competition. There is, however, a second, less-obvious harm from this phenomenon. Discouraging research by nascent firms undermines the creation of potentially ground-breaking technologies, which commonly arise from less mature companies (i.e., those owning fewer patents).<sup>171</sup> Concentrations of patents thus

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<sup>167</sup> See Peter Menell, *Forty Years of Wondering in the Wilderness and No Closer to the Promised Land: Bilski's Superficial Textualism and the Missed Opportunity to Return Patent Law to Its Technology Mooring*, 63 STAN. L. REV. 1289, 1306 (2011).

<sup>168</sup> Feng-Jui Hsu et al., *An Empirical Study on the Relationship Between R&D and Financial Performance*, 3 J. APPLIED FIN. & BANKING 107, 108 (2013) (stating that “firm performance is positively correlated with the number of patents the firm owns”); Gary L. Lilien & Eunsang Yoon, *Determinants of New Industrial Product Performance: A Strategic Reexamination of the Empirical Literature*, 36 IEEE TRANSACTIONS ON ENGINEERING MGMT. 3, 3-8 (1989) (asserting that firms holding more are more likely to innovate and improve existing products); Ashish Arora, et. al, *R&D and the Patent Premium*, 26 INT’L J. OF INDUSTRIAL ORGANIZATION 1153–1179 (2008) (“the patent premium for innovations that were patented is substantial. Firms earn on average a 50% premium over the no patenting case, ranging from 60% in the health related industries to about 40% in electronics.”).

<sup>169</sup> Indeed, as set forth in Section **Error! Reference source not found.**(B), articles describe negative externalities associated with over-patenting, including patent thickets that undercut firm profits. Entezarkheir, *supra* note 82. Large portfolios may also produce barriers to entry, Cohen, *supra* note 59, at 62 which preclude competition and elevate consumer prices. Stephen Gillers, *The Year: 2075 the Product: Law*, 1 J. INST. STUD. LEGAL ETHICS 285, 292 (1996). Others hypothesize that, within particular industries, substantial patent holdings may discourage corporate research. *Id.* at 698–701.

<sup>170</sup> Hall, *supra* note 59, at 109-110.

<sup>171</sup> Clayton M. Christensen, *THE INNOVATOR'S DILEMMA: WHEN NEW TECHNOLOGIES CAUSE GREAT FIRMS TO FAIL* 134 (1997) (smaller organizations are better suited to created disruptive technologies); David Abrams & Polk Wagner, *Poisoning the Next Apple? The America Invents Act and Individual Inventors*, 65 STAN. L. REV. 517, 530 (2013) (“[T]here is some evidence that the inventions from smaller entities are more likely to be disruptive in nature, moving the pace of technological change forward.”); Amy L. Landers, *The Antipatent: A Proposal for Startup Immunity*, 93 NEB. L. REV. 950, 1004 (2015) (“[S]mall firms to lead the way for certain types of technological innovation.”).

deprive the public of research that can both create market competition and introduce particularly important innovations.

Recognizing these shortcomings of the current system, we now propose methods to correct this misalignment. As set forth in the following subpart, our findings provide necessary empirical backing to proposals to discourage over-patenting and its associated ills.

### *B. Culling Low-Value Patents*

Our proposals to bolster innovation concern slight changes to the underlying economics of patent rights. Currently (and historically) the free market determines a patent's value; since each patent costs the same regardless of the invention, firms should only patent technology ascribed sufficient value by the market. But when firms build an arsenal, the constituent patents receive a value beyond what the market would otherwise recognize. Considering that culling low-value patents would generate innovation,<sup>172</sup> the task is to adjust this system so that the value of each patent more closely reflects the value of the underlying technology. Proposed avenues include instituting a working requirement, shifting the burden of inspecting a patent, and introducing a sliding scale of maintenance fees.

#### 1. Working Requirement

The literature recognizes that certain firms maintain arsenals to discourage lawsuits,<sup>173</sup> license to competitors,<sup>174</sup> or preclude the patenting of a technology by another.<sup>175</sup> None of these strategic uses of the IP system entail protecting or producing technologies embodied in a new product. In fact, this type of activity furthers patent thickets, which as described above, discourages research expenditures. It would thus serve society to discourage patenting of this nature.

To dissuade firms from engaging in purely strategic patenting, countries may implement a patent working requirement—mandating that to maintain protection, either the patent owner or licensee must use the claimed technology within the country.<sup>176</sup> A domestic provision of this nature would discourage companies from strategically patenting inventions that they harbor no

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<sup>172</sup> See *supra* Section III(E&F).

<sup>173</sup> Colleen V. Chien, *From Arms Race to Marketplace: The Complex Patent Ecosystem and Its Implications for the Patent System*, 62 HASTINGS L.J. 297, 317 (2010).

<sup>174</sup> Tom Ewing, *Indirect Exploitation of Intellectual Property Rights By Corporations and Investors: IP Privateering and Modern Letters of Marque and Reprisal*, 4 HASTINGS SCI. & TECH. L.J. 1, 27 (2012).

<sup>175</sup> W. Michael Schuster, *Artificial Intelligence and Patent Ownership*, 75 WASH & LEE L. REV. 1946, 1983 (2018).

<sup>176</sup> Marketa Trimble, *Patent Working Requirements: Historical and Comparative Perspectives*, 6 U.C. IRVINE L. REV. 483, 484 (2016).

interest of using in commerce. This, in turn, prevents the harms associated with over-patenting that we describe above (e.g., diminished R&D expenditures).

Implementation of a working requirements would necessitate that patentees file a statement of use (i.e., making bona fide use of the technology) at given intervals or abandon the subject patent.<sup>177</sup> While our goal sought by this requirement diverges from earlier proposals of this sort (e.g., ensuring access to medicine<sup>178</sup>), the effect remains. Firms would be limited in their ability to patent technologies for purely strategic purposes, which would cull low-value patents and encourage future research. Similarly, firms would be incentivized to satisfy the working requirement by licensing their technologies to others on equitable terms. This decreases hold out behaviors associated with strategic patenting (e.g., demanding exorbitant sums for a license)<sup>179</sup> and diminishes harms associated with the Tragedy of the Anti-Commons (e.g., the inability to bring products to market due to the necessity of securing costly patent licenses).<sup>180</sup> An additional benefit is that prospective inventors would only be required to identify pre-existing patents found in active products, which would decrease the costs and risks of innovation. Again, the current research encourages such policies to maximize the goals of the patent system, namely encouraging the creation of new technologies.

## 2. Shifting Inspection Fees

A more radical approach would be to shift the burdens of inspecting patents. A chief reason why strategic patenting deters competition is that the costs to inspect each patent in an arsenal is typically cost prohibitive. This reality has prompted firms to purchase thousands of patents on the market, as the cost to acquire an arsenal is cheaper than the costs imposed on competitors.<sup>181</sup> Because the result of this strategy is diminished innovation (as we demonstrated in the prior Part), patent law should consider shifting inspection costs onto the owner of arsenals.

To do so, the patent system may create a threshold number of patents in an industry; the crossing of this threshold would suggest that the patent owner is strategically impeding innovation. For instance, the line could be drawn at 500 patents within a certain industry based on NAICS industry codes. If a patentee claims over 500 patents, a junior inventor could request from the

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<sup>177</sup> See Maayan Perel, *From Non-Practicing Entities (Npes) to Non-Practiced Patents (Npps): A Proposal for a Patent Working Requirement*, 83 U. CIN. L. REV. 747, 793 (2015).

<sup>178</sup> Bryan Mercurio & Mitali Tyagi, *Treaty Interpretation in WTO Dispute Settlement: The Outstanding Question of the Legality of Local Working Requirements*, 19 MINN. J. INT'L L. 275, 284 (2010).

<sup>179</sup> See *supra* footnote 68 and associated text.

<sup>180</sup> See *supra* footnote 67 and associated text.

<sup>181</sup> See Lemley & Melamed, *supra* note 28, at 2127 (describing the “patent aggregator” which accrues such a critical number of patents to make inspection impossible: “Scale is critical to this model. Patent aggregators depend on sheer numbers rather than the quality and value of any given patent. Their scale enables them to license without litigation because defendants are reluctant to challenge an entire portfolio of patents.”).

senior owner whether the junior's proposed technology infringes on any of the senior owner's patents, relocating the burden of inspection onto the arsenal owner. This request would also vest the junior inventor with priority over the technology if the senior owner has yet to patent the technology or fails to identify the relevant patent. In situations where a dispute arises—e.g., the senior owner alleges a certain patent covers the technology where the junior owner disagrees—the conflict could be resolved by the Patent Trial and Appeal Board (“PTAB”), which is known for its cheaper and more expedient process to review a challenged patent.<sup>182</sup>

The benefits of this proposal are many. First, it would give the duty to inspect a portfolio on the party who has the best knowledge of those patents, namely the actual patent owner. Further, the cumulative effect would be that firms, in hoping to avoid this threshold, would encounter incentives to maintain only valuable patent rights, reducing the anti-commons. An incidental effect could also cause firms with legitimate patent holdings near the threshold level to shift their efforts into relatively unexplored areas of technology where fewer patents exist, promoting a diversity of innovation. This proposal would thus help to remove the economic incentives of strategic patenting, allowing the market to price the value of an invention.

That said, there are problems. Such a proposal would increase the costs of inventing by imposing an affirmative duty on firms to provide inspection services for smaller inventors. There is also the chance of abuse by smaller firms who could overwhelm larger firms. While safeguards could be imposed against abuse, the law has traditionally struggled to counter strategies used by firms to game a system. Another problem is that failure to identify each relevant patent would require the firm to lose its claim against that inventor; this failure to inspect would essentially cause the inventor to abandon its patent rights despite innovating original technology.

### 3. Sliding Scale of Fee Magnitude

Relevant literature presents a simple solution to the existence of too many patents. Financial disincentives can discourage prosecution of low-value applications<sup>183</sup> and encourage expiration of minimal worth patents.<sup>184</sup> Empirical research (along with basic economic theory)

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<sup>182</sup> See W. Michael Schuster, *Invalidity Assertion Entities and Inter Partes Review: Rent Seeking as a Tool to Discourage Patent Trolls*, 51 WAKE FOREST L. REV. 1163, 1171-72 (2016) (explaining the cost effective nature of litigation in the PTAB process).

<sup>183</sup> Burk, *supra* note 9, at 1575.

<sup>184</sup> Brian J. Love, *To Improve Patent Quality, Let's Use Fees to Weed Out Weak Patents*, BERKELEY TECH. L.J. COMMENTARIES, at 2 (Mar. 12, 2016).

supports achieving these goals by increasing costs to secure and maintain patents.<sup>185</sup> Legal commentators have proposed solutions in this vein.<sup>186</sup>

Elevating fees associated with patent activity would discourage patenting of low-value inventions for the purpose of creating a strategic arsenal. Across the board increases in application and maintenance fees are, however, a needlessly blunt tool to the extent that they discourage patent activities equally for *all* parties. Generally elevating the cost of ownership could concentrate patent holdings in the hands of larger, entrenched firms that can afford the costs.<sup>187</sup> Further and perhaps more importantly, the level of deterrence would be the same for parties with small holdings (who presumptively only patent valuable inventions) and owners of large portfolios, which the current study finds will pay to own patents that others deem worthless. An ideal regime discourages the grant and maintenance of these less valuable patents.

Our findings support a system of escalating patent fees (both issue and maintenance) relative to the patentee's current holdings. As discussed above, owners of large portfolios continue prosecution of patent applications that others would allow to go abandoned and, relatedly, pay maintenance fees where other firms would not. Imposing financial disincentives on these large holders would thus reduce the aggregate number of low-value patents being secured or maintained only to be part of a patent arsenal (and the negative externalities associated with such behaviors).<sup>188</sup>

As discussed in Section II(C), we hypothesized (and the data supports) that owners of large portfolios attribute some discrete value to a current or future patent associated with its place in the portfolio. This value is in addition to the exclusionary benefit that all owners enjoy. The ideal fee increase for holders of many patents would offset this "portfolio premium," such that *all* patent owners would only secure and maintain patents if the traditional exclusionary value exceeds associated costs. Thus, if the owner of a large arsenal values a patent as \$X (the traditional benefit associated with the invention itself) plus \$Y (the value associated with the patents inclusion in a portfolio), the additional fee would be equal to \$Y. In such a situation, obtaining and maintaining low-value patents is discouraged, but the incentive to patent valuable inventions remains constant for all parties.

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<sup>185</sup> de Rassenfosse, *supra* note 58, at 144.

<sup>186</sup> Colleen V. Chien, *Reforming Software Patents*, 50 HOUS. L. REV. 325, 360-61; Neel U. Sukhatme, *Regulatory Monopoly and Differential Pricing in the Market for Patents*, 71 WASH & LEE L. REV. 1855, 1897; Troy L. Gwartney, Note, *Harmonizing the Exclusionary Rights of Patents with Compulsory Licensing*, 50 WM. & MARY L. REV. 1395, 1425-26.

<sup>187</sup> Jeremy W. Bock, *Patent Quantity*, 38 U. HAW. L. REV. 287, 316-317

<sup>188</sup> Safeguards would need to be put in place to avoid parties strategically allocating ownership among many subsidiaries. For instance, related firms who enjoy cross-licensing agreements or who practice patents held by related firms could be considered to "own" all of the patents held by the related firms.

We are not the first to suggest a sliding scale for fees associated with patent ownership. For instance Olson suggested elevated maintenance fees for owners of many nonpracticed patents,<sup>189</sup> while Parchomovsky and Wagner discussed across the board fee increases for owners of large portfolios.<sup>190</sup> This article is, however, the first to present empirical evidence that a proposed sliding scale would disproportionately target owners of weak patents, and in turn, diminish the harms of patent thickets. Restated, our findings establish a premium that owners of patent arsenals place on their patents, which could be offset via targeted increases in patent fees. This would return the patent incentive structure to its traditional moorings of encouraging the patenting of only valuable inventions.

### **Conclusion**

This Article addresses societal effects of over-patenting. It is the first to present empirical evidence establishing the connection between strategic patent portfolios and decisions to obtain and maintain patents regardless of the patent's value. Restated, firms holding large portfolios are, all else being equal, more likely to pay to obtain or maintain a patent.

Building from this, we analyze the effect that these large patent holdings have on innovation. The evidence supports the conclusion that, despite arguments from industry advocates, not all patents are good for innovation. In fact, we find an overall inverse correlation between industry-wide patents and firm R&D expenditures. We do, however, find this effect to reverse for firms holding substantial portfolios. Accordingly, entrenched firms continue research and associated patenting, while others reduce R&D expenditures. As discussed herein, this disparity furthers barriers to entry in fields with many patents, thus discouraging market competition and benefits associated therewith. Premised on this data, the article concludes by proffering real world policy suggestions to improve domestic innovation.

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<sup>189</sup> David 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, 522 (2016). Olson argues that his "proposal will reduce problems associated with the abusive use of patent portfolios without significantly reducing incentives to innovate and to disseminate that innovation." *Id.* at 521.

<sup>190</sup> Parchomovsky, *supra* note 9, at 68-69 (stating that "[f]irms with larger holdings would face higher fees, thereby providing some disincentive to adopt a high-volume, low-quality patenting strategy," before the authors ultimately suggested another policy choice).



## Appendix

**Table 5. Fixed Effects Regression**

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	<u>Model</u> 5
<i>Time Spent to Complete the Patent Process (Pendency)</i>	
Numb. of Claims	<b>2.027725***</b> (.0285459)
Numb. of Parents	<b>-2.492437***</b> (.3933244)
Numb. of Inventors	<b>7.869023***</b> (.2323972)
Numb. of Patents Citing	<b>.3629428***</b> (.0086226)
Portfolio Size	<b>.0043041***</b> (.0000699)
GDP Control	<b>8.843874***</b> (.3477006)
Constant	<b>788.2047***</b> (22.03001)
Prob > F	<b>0.0000***</b>
R-Squared	0.0282
No. of Observations	1003286

\*p<0.10, \*\*p<0.05, \*\*\*p<0.01

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**Table 6. Survival Analysis**

	<u>Model</u> 6
<i>Likelihood of Patent Lapsing</i>	
Numb. of Claims	<b>-.0086524***</b> (.0001088)
Numb. of Parents	<b>-.0133489***</b> (.0012942)
Numb. of Inventors	<b>-.0145314***</b> (.0007837)
Numb. of Patents Citing	<b>-.0072974***</b> (.0000524)
Biology Dummy	<b>.080798***</b> (.0040164)
Chemicals Dummy	.0031293** (.003195)
Portfolio Size	
Small Entity Dummy	<b>.6227863***</b> (.0025959)
GDP Control	<b>.0036423 ***</b> (.0009278)
Revenue	
Prob > chi2	<b>0.0000***</b>
No. of Subjects	1391336
*p<0.10, **p<0.05, ***p<0.01	

**Table 7. Survival Analysis**

	<u>Model</u> 7	<u>Model</u> 8
<i>Likelihood of Patent Lapsing</i>		
Numb. of Claims	<b>-.0078241***</b> (.0003202)	<b>-.0078849***</b> (.0003202)
Numb. of Parents	<b>.0170699***</b> (.0038096)	<b>.0144166***</b> (.0038096)
Numb. of Inventors	-.0028163 (.0021423)	-.0023747 (.0021423)
Numb. of Patents Citing	<b>-.0091267***</b> (.0001507)	<b>-.0091453***</b> (.0001507)
Portfolio Size	-.0000504*** (.003035)	<b>-.00000298***</b> (.00000108)
Small Entity		<b>.6227863***</b> (.0232686)
Assets Owned	-.00000349*** (.0000000354)	<b>-.000000302***</b> (.0000000354)
Assets*Numb. Holdings	<b>.00000000313***</b> (-.000000000116)	<b>.00000000294***</b> (.000000000116)
GDP Control	<b>.0313053***</b>	<b>.0317934***</b>

(.003035)

(.003035)

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Prob > chi2	<b>0.0000***</b>	<b>0.0000***</b>
No. of Subjects	181311	181311

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\*p<0.10, \*\*p<0.05, \*\*\*p<0.01

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