DETERMINANTS OF PATENT QUALITY: EVIDENCE FROM INTER PARTES REVIEW PROCEEDINGS

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We study the determinants of patent "quality"—the likelihood that an issued patent can survive a post-grant validity challenge. We do so by taking advantage of two recent developments in the United States patent system. First, rather than relying on the relatively small and highly selected set of patents scrutinized by courts, we study the larger and broader set of patents that have been subjected to inter partes review, a recently established administrative procedure for challenging the validity of issued patents. Second, in addition to analyzing characteristics observable on the face of challenged patents, we utilize datasets recently made available by the United States Patent and Trademark Office (USPTO) to gather detailed information about the prosecution and examination of studied patents. We find a significant relationship between validity and a number of characteristics of a patent and its owner, prosecutor, examiner, and prosecution history. For example, patents prosecuted by large law firms, pharmaceutical patents, and patents with more words per claim are significantly more likely to survive inter partes review. On the other hand, patents obtained by small entities, patents assigned to examiners with higher allowance rates, patents with more US patent classes, and patents

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with higher backward citation counts are less likely to survive review. Our results reveal a number of strategies that may help applicants, patent prosecutors, and USPTO management increase the quality of issued patents. Our findings also suggest that inter partes review is, as Congress intended, eliminating patents that appear to be of relatively low quality.

INTRODUCTION

In theory, the patent system allows firms to treat their inventions as liquid assets that can be transferred to others better positioned to use them via a thick secondary market that indirectly matches inventors and implementers.[1] In this way, ideas (like capital) can flow to their highest and best use, guided by the invisible hand of the market. But reality falls short of this ideal. Unlike stocks, bonds, and other securities, there is to date no generally accepted methodology for evaluating patents. Consequently, rather than exhibiting robust liquidity, the market for patents is thin, opaque, and based largely on the value of ex post assertion against independent inventors, rather than ex ante licensing to eager commercializers.[2]

The result is a patent system all too often plagued by strategic behavior. For example, a lack of reliable methods for measuring patent scope and quality contributed to the rise of "patent assertion entities" (PAEs)—patent monetization specialists that are uniquely able to wield various forms of "holdup" power over the parties they sue in order to extract set-

1. *See* Edmund W. Kitch, *Elementary and Persistent Errors in the Economic Analysis of Intellectual Property*, 53 VAND. L. REV. 1727, 1740 (2000) ("[T]he ability of the owners of intellectual property rights to transfer these rights in whole or in part to others is an important feature of the systems . . . [because] rights can easily arise in the hands of persons or firms who are not in the best position to exploit them."); *see also* Amy L. Landers, *Liquid Patents*, 84 DENV. U. L. REV. 199, 211–14 (2006) (describing ways in which the patent system facilitates the transfer of patent rights); Michael Risch, *Patent Portfolios as Securities*, 63 DUKE L.J. 89, 93 (2013) (proposing that patent portfolios be regulated like securities).

2. *See* Brian J. Love et al., *An Empirical Look at the "Brokered" Market for Patents*, 83 MO. L. REV. 359 (2018) (collecting data on patents offered for sale by patent brokers between 2012 and 2016); Mark A. Lemley & Nathan Myhrvold, *How to Make a Patent Market*, 36 HOFSTRA L. REV. 257, 257–59 (2007) (describing problems created by the "blind market" for patents).

tlements that reflect more than the value of the asserted patent.[3] Conversely, the costs inherent in participating in an inefficient market contribute to the fact that many tech companies choose to turn a blind eye to the market entirely, a practice decried by many patentees as "holdout" behavior designed to raise the cost of patent enforcement.[4]

In an attempt to make the market more efficient and thereby reduce holdup and holdout, legal scholars, economists, and business professionals have experimented for years with methodologies for quickly assessing the scope and quality of a given patent or portfolio.[5] But so far, reliable solutions have proven elusive.[6] Indeed, even companies that prosecute large

3. *See* Andrei Hagiu & David B. Yoffie, *The New Patent Intermediaries: Platforms, Defensive Aggregators, and Super-Aggregators*, 27 J. ECON. PERSP. 45, 51 (2013) ("In essence, nonpracticing entities act as arbitrageurs, first acquiring patents, typically from individual inventors or small companies, and then seeking licensing revenues from operating companies through litigation . . . ."). The term "patent assertion entity" is typically defined to encompass all non-practicing patent enforcers, except universities, early stage startups, and IP holding subsidiaries of operating technology companies. *See* Brian J. Love, Assistant Professor of Law, Santa Clara University, Testimony at the Informational Hearing on Patent Assertion Entities Before the California Assembly Select Committee on High Technology (Oct. 30, 2013), http://papers.ssrn.com/sol3/papers.cfm.?abstract_id=2347138 [https://perma.cc/2U4U-FM86]. Because PAEs do not compete with the companies that they sue, they are able to take advantage of several holdup opportunities that are generally not available to operating companies. For example, because PAEs do not sell products that compete with those produced by alleged infringers, they are able to avoid countersuit and thus can generally leverage asymmetric litigation costs against the parties they sue. *See id.* In addition, because PAEs sue to recover monetary damages rather than injunctions to protect market share, they can strategically delay suit until alleged infringers are "locked in" to using the allegedly infringing technology and, thus, cannot easily switch to a non-infringing alternative. *See* Colleen V. Chien, *Holding Up and Holding Out*, 21 MICH. TELECOMM. & TECH. L. REV. 1, 14 (2014) ("By pursuing a patent license ex post, after a product has been created, rather than ex ante, at the time the product is being designed, the patent owner can leverage not only the economic value of the invention, but also the cost of changing the product.").

4. *See* Chien, *supra* note 3, at 20 (defining patent holdout as "the practice of companies ignoring patents and patent demands because the high costs of enforcing patents makes prosecution unlikely").

5. *See, e.g.*, Anne Kelley, *Practicing in the Patent Marketplace*, 78 U. CHI. L. REV. 115, 116–17 (2011) ("[B]oth scholars and practitioners are seeking ways to improve how patents are valued, with scholars often calling for greater disclosure of sale terms to aid in setting market prices and practitioners focusing on refining methods for predicting a patent's value to their own clients.").

6. *See, e.g.*, Kevin G. Rivette et al., *Discovering New Value in Intellectual Property*, HARV. BUS. REV. 54, 66 (Jan.–Feb. 2000) ("[O]ne would be hard-pressed to find a major investment bank that employs even one individual with experience

patent portfolios covering their own technologies are often unable to reliably identify their best patents. Consider, for example, the fact that large tech companies routinely lose multi-million dollar patent suits—even when the patents they assert were previously deemed "essential" to important technology standards.[7] Overall, asserted patents are at least partially invalidated about 40 percent of the time when validity is litigated,[8] and overall patentees win only about one-quarter of patent cases litigated to a decision on the merits.[9]

In addition to vexing patent owners, there is reason to believe that the patent system's failure to reliably produce valid patents has broad implications for the economy and innovation generally. Uncertainty about patent quality generates transaction costs for companies attempting to navigate the patent landscape.[10] In addition to slowing the pace of research and development at existing firms, these costs can deter companies

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in evaluating patent portfolios. . . . [A]s matters stand now, 'due diligence' regarding patent assets is usually more myth than reality."); Markus Reitzig, *Improving Patent Valuations for Management Purposes: Validating New Indicators by Analyzing Application Rationales*, 33 RES. POL'Y 939, 939 (2004) ("[D]espite the diversity of articles from Industrial Organization (IO) or legal scholars on value related issues of intellectual property rights, there is a lack of scientific papers that restructure the knowledge on the evaluation of patent rights from a corporate perspective.").

7. *See* RPX CORP., STANDARD ESSENTIAL PATENTS: HOW DO THEY FARE? (2014), https://www.rpxcorp.com/wp-content/uploads/2014/01/Standard-Essential-Patents-How-Do-They-Fare.pdf [https://perma.cc/6Z8B-TRGM] (finding that plaintiffs like Nokia, Motorola, Samsung, and others successfully enforced standard-essential patents just 12 to 29 percent of the time between 2005 and June 2014).

8. *See* John R. Allison et al., *Understanding the Realities of Modern Patent Litigation*, 92 TEX. L. REV. 1769, 1787 (2014) (collecting statistics for all patent cases filed in 2008 and 2009).

9. *Id*. at 1788. *See also* Shawn P. Miller, *Where's the Innovation: An Analysis of the Quantity and Qualities of Anticipated and Obvious Patents*, 18 VA. J.L. & TECH. 1, 6–7 (2013) (estimating that more than one quarter of all granted U.S. patents would be found at least partially anticipated or obvious if litigated).

10. *See* Bronwyn H. Hall & Dietmar Harhoff, *Post-Grant Reviews in the U.S. Patent System: Design Choices and Expected Impact*, 19 BERKELEY TECH. L.J. 989, 992 (2004) ("Low quality patents can create considerable uncertainty among inventors or would-be commercializers of inventions, which in turn can slow either the pace of innovation or investment in the commercialization of new technologies."); Joseph Farrell & Carl Shapiro, *How Strong Are Weak Patents?*, 98 AM. ECON. REV. 1347, 1361 (2008) (presenting an economic model predicting that weak patents can nonetheless command substantial royalty payments and concluding that "[t]here are large social benefits, ex post and, perhaps more importantly, ex ante, of better examining commercially significant patents").

from entering a market in the first place[11] and discourage them from combining complementary technologies to form new ones.[12]

As a result, patent policymakers have long sought guidance on how to design patent office procedures that produce high-quality patents. In 2015, the U.S. Patent and Trademark Office (USPTO) launched a "Patent Quality Initiative" overseen by a newly created "Deputy Commissioner for Patent Quality."[13] Similarly, the European Patent Office (EPO) formed a "Working Party on Patent Quality" in 2017,[14] and the Japanese Patent Office (JPO) released a new "Quality Policy on Patent Examination" in 2014 and published a "Quality Management Manual" for patent examiners in 2016.[15]

Despite intense interest, however, to date there have been relatively few formal studies of patent quality. Among other reasons, both public and private studies of patent quality have been hindered by two methodological obstacles. The first is a paucity of post-grant decisions on patent validity. While thousands of patent suits are filed each year, just a tiny fraction are litigated to a decision on the merits.[16] And, even

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11. *See* Josh Lerner, *Patenting in the Shadow of Competitors*, 38 J.L. & ECON. 463, 489–90 (1995) (finding in a study of 419 biotechnology companies that smaller firms with relatively high litigation costs are less likely to file for patents in technology areas where established competitors with relatively low litigation costs have already been granted patents).

12. *See* Michael A. Heller & Rebecca S. Eisenberg, *Can Patents Deter Innovation? The Anticommons in Biomedical Research*, 280 SCIENCE 698 (1998) (arguing that a proliferation of overlapping patent rights to technologies can create an "anticommons" that deters the commercialization of new products).

13. *Patent Quality*, U.S. PATENT & TRADEMARK OFFICE, https://www.uspto.gov/patent/patent-quality (last visited July 27, 2017) [https://perma.cc/8UBX-YL7Z].

14. *Engaging with Users on Patent Quality*, EUROPEAN PATENT OFFICE (Jan. 24, 2017), https://www.epo.org/news-issues/news/2017/20170124.html [https://perma.cc/9SSW-9ZU6].

15. *Quality Management on Patent Examination*, JAPAN PATENT OFFICE, https://www.jpo.go.jp/seido_e/quality_mgt/patent.htm (last visited July 27, 2017) [https://perma.cc/CK4J-ALFS].

16. According to Lex Machina, just 4 percent of patent cases filed between 2000 and 2015 were litigated to a jury verdict, grant of summary judgment, or judgment as a matter of law. Case Resolutions for District Court Patent Cases Filed 2000–2015, LEX MACHINA, INC., https://lexmachina.com/ (search conducted July 27, 2017) [https://perma.cc/ZS4A-JP66]. In a study of all patent cases filed in 2008 and 2009, Allison et al. found just 430 decisions on validity that represented an (at least partial) "win" for either the patentee or a defendant. Allison et al., *supra* note 8, at 1778. Moreover, these decisions likely involved fewer than 430 unique patents. *Id.* (noting that the 949 total decisions studied involved 777

when cases are litigated to a decision on validity, many such decisions address only a subset of the claims or arguments at issue in the case.[17] Many others are later reversed on appeal.[18] Moreover, those that are litigated are highly selected. Indeed, there is reason to believe that the most vulnerable litigated patents are those least likely to be challenged on the merits in court.[19] As a result, prior studies often analyzed relatively small, disparate samples of patents, making their findings hard to generalize.[20]

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unique patents).

17. According to Docket Navigator, only about 28 percent of decided motions for summary judgment of invalidity are granted in full. Document Search for "Motion for Summary Judgment – Patent Invalid," DOCKET NAVIGATOR, INC., https://www.docketnavigator.com/ (search conducted Aug. 1, 2017) [https://perma.cc/YB3V-W23G]. Moreover, motions granted in full will themselves often only relate to a subset of claims at issue in a case.

18. Overall, the Court of Appeals for the Federal Circuit reverses in about 15 percent of appeals, and the rate has historically been much higher for appeals involving a review of claim construction. *See* Ted M. Sichelman, *Myths of (Un)Certainty at the Federal Circuit*, 43 LOY. L.A. L. REV. 1161 (2010); J. Jonas Anderson & Peter S. Menell, *Informal Deference: A Historical, Empirical, and Normative Analysis of Patent Claim Construction*, 108 NW. U. L. REV. 1 (2013); Shawn P. Miller, *"Fuzzy" Software Patent Boundaries and High Claim Construction Reversal Rates*, 17 STAN. TECH. L. REV. 809 (2014). Claim construction is an integral part of adjudicating patent quality as it is generally the first step to both infringement and validity analysis. *See* Cybor Corp. v. FAS Techs., Inc., 138 F.3d 1448, 1456 (Fed. Cir. 1998) (en banc).

19. A substantial portion of patent suits filed by non-practicing entities settle quickly, often in a matter of months, for amounts that fall below defendants' expected cost of defense. *See* FED. TRADE COMM'N, PATENT ASSERTION ENTITY ACTIVITY: A FTC STUDY 4–5 (2016), https://www.ftc.gov/reports/patent-assertion-entity-activity-ftc-study [https://perma.cc/HJ66-H3H6] (finding that the majority of patent suits filed by "Litigation PAEs" settled within one year of filing and for less than $300,000, an amount that "approximates the lower bound of early-stage litigation costs of defending a patent infringement suit"). Few defendants would rationally choose to defend such cases on the merits, and thus many patents asserted in such cases are rarely, if ever, subjected to validity challenges in court. *See* Love, *supra* note 3, at 3 ("If . . . the costs of defense . . . are large relative to the value of the patented technology at issue, then the strength of their infringement allegations quickly becomes irrelevant. Tech companies accused of infringing a PAE's patent will be willing to—and, in fact, generally do—settle for amounts that primarily reflect the cost of fighting in court, and not the value of the patent that is allegedly infringed.").

20. *See* John R. Allison & Mark A. Lemley, *Empirical Evidence on the Validity of Litigated Patents*, 26 AIPLA Q.J. 185, 194 (1998) (studying all 299 patents that were the subject of a final validity decision reported in the United States Patents Quarterly between 1989 and 1996); Ian M. Cockburn et al., *Are All Patent Examiners Equal? Examiners, Patent Characteristics, and Litigation Outcomes*, *in* PATENTS IN THE KNOWLEDGE-BASED ECONOMY 17, 19 (Wesley M. Cohen & Stephen A. Merrill eds., 2003) (studying "182 patents for which the

The second obstacle is difficulty obtaining detailed information about individual patents. Until recently, U.S. patent-level data were spread across numerous databases, each designed to prevent the automatic collection of information by members of the public.[21] As a result, many prior studies looked only at information that could be collected from the face of studied patents.[22] But doing so prevented researchers from including in their analyses detailed information about patents' prosecution histories, including characteristics of prosecution counsel and the examiners assigned to applications.

In this paper, we take advantage of two recent developments in the U.S. patent system that make it possible to study patent quality more comprehensively than ever before. First, rather than relying on the set of patents scrutinized by courts or juries in recent years, we study the larger set of patents that have been subjected to inter partes review, a recently established administrative procedure for challenging the validity of issued patents. Second, rather than relying solely on characteristics observable on the face of studied patents, we query datasets recently made available by the USPTO to gather detailed information about the prosecution and examination of studied patents.[23] Our study is, we believe, the largest and most comprehensive examination of patent quality conducted to

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Court of Appeals for the Federal Circuit (CAFC) ruled on validity between 1997 and 2000"); Ronald J. Mann & Marian Underweiser, *A New Look at Patent Quality: Relating Patent Prosecution to Validity*, 9 J. EMP. L. STUD. 1, 7 (2012) (studying all 366 patents that were the subject of Federal Circuit invalidity decisions made from 2003 through 2009); Ronald J. Mann, *The Idiosyncrasy of Patent Examiners: Effects of Experience and Attrition*, 92 TEX. L. REV. 2149, 2158 (2014) (studying "a data set of 366 patents, which constitute the universe of patents for which the Federal Circuit issued a final decision on validity during the period 2003–2009"); Yutaka Niidome, *The Relation of Patent Description and Examination with Validity: An Empirical Study*, 111 SCIENTOMETRICS 159, 168, 171 (2017) (studying all 267 patents that (1) had an application date between October 2001 and December 2004, (2) were granted before April 2014, and (3) were the subject of a completed validity challenge decided by the JPO's Board of Appeals). *But see* Miller, *supra* note 9, at 16 (studying the population of 980 patents with final validity decisions on the grounds of anticipation and obviousness—the only bases for review in inter partes review—among all lawsuits filed in the eleven years from 2000 through 2010).

21. For example, the USPTO's "Patent Application Information Retrieval" (PAIR) database, https://portal.uspto.gov/pair/PublicPair, periodically requires users to complete a "captcha" to prevent the automatic collection of data about the prosecution of patent applications.

22. *See, e.g.*, studies cited *infra* notes 27–33.

23. *See infra* notes 195–196.

date.

Our multivariate analysis, which controls for almost two-dozen attributes of challenged patents, suggests that among other things:

- Patents owned by patent assertion entities (PAEs) and non-practicing entities (NPEs) are significantly more likely (by about 7 and 5 percent, respectively) to be "instituted" (i.e., found "reasonabl[y] likel[y]" to have at least one invalid claim[24]) when challenged in inter partes review;
- High-tech patents are neither more nor less likely to be instituted, whereas pharmaceutical patents are between 6 and 11 percent less likely to be instituted;
- Patents applied for by "small entities" and patents prosecuted by solo practitioners are each 5 percent more likely to be instituted, whereas patents prosecuted by large law firms are 6 percent less likely to be instituted;
- Patents assigned to more U.S. patent classes (USPCs) are more likely to be instituted, with each additional class associated with a 0.6 percent increase in the chance of institution;
- Patents with more total words per claim and patents with more unique words in claim 1 are both less likely to be instituted, with an increase of one thousand total words per claim or an increase of ten additional words in claim 1 each associated with a 1 percent decrease in the chance of institution;
- Patents with more backward citations (i.e., citations to relevant prior art) and patents with more backward citations added by the examiner are both *more* likely to be instituted, with an additional 10 backward citations associated with a 0.15 percent increase in the chance of institution, and an additional 10 backward citations added by the examiner associated with a 1.8 percent increase in the chance of institution; and
- Patents reviewed by more experienced examiners, patents

24. 35 U.S.C. § 314(a) (2012) ("The Director may not authorize an inter partes review to be instituted unless the Director determines that . . . there is a reasonable likelihood that the petitioner would prevail with respect to at least 1 of the claims challenged in the petition.").

> reviewed by examiners with higher allowance rates, and patents reviewed by examiners in art units with higher allowance rates are all more likely to be instituted, with a roughly 2.5 percent increase in the likelihood of institution associated with each additional 1,000 applications assigned to an examiner in his or her career, with each 10 percent increase in an examiner's allowance rate, and with each 10 percent increase in an art unit's allowance rate.

In addition to advancing the literature on patent quality, our findings have importance for ongoing policy debates. As described in detail *infra* in Section II.D.3, the continued existence of administrative patent challenges in the United States is uncertain. In both Congress and the courts, opponents of post-grant administrative review have sought to weaken or altogether eliminate existing procedures. At the core of this policy debate is a dispute about whether, on balance, administrative review of issued patents helps or harms innovation. Our results suggest that inter partes review is, on average, eliminating patents with characteristics traditionally associated with "weakness" and, thus, are consistent with arguments that the procedure is functioning as originally intended.

The paper proceeds as follows: Part I provides a brief review of the existing academic literature on patent value and quality. Part II briefly describes ex ante patent examination and post-grant patent challenges. Part III describes our data collection methodology, and Parts IV and V report our findings and discuss their implications.

I. PATENT "VALUE" AND PATENT "QUALITY"

Patents (unlike the technologies that they cover) have no inherent worth; rather, they entitle their owner to seek redress against an alleged infringer by filing a lawsuit.[25] To successfully litigate a patent infringement claim, a patent owner must

25. *See* Jonathan S. Masur, *The Use and Misuse of Patent Licenses*, 110 NW. U. L. REV. 115, 127 (2015) ("No one would ever license a patent absent the threat of litigation. If a patent holder could not threaten to enforce its patent against a putative licensee in court, the licensee would have no reason to negotiate a license in the first place. Patent licenses are best understood as civil settlements in anticipation of possible litigation.").

prove that the allegedly infringing products or actions fall within the scope of a patent claim and must successfully defend against the accused infringer's inevitable defense that the asserted patent claim fails to satisfy the requirements for patent protection (and, thus, should never have been issued in the first place).[26] In this Part, we summarize existing research regarding the relationship between the observable characteristics of a patent and its value or quality.

A. Patent Value

For decades, scholars have studied the relationship between a patent's importance and its observable characteristics. The earliest, and most developed, of these lines of research examines patent citations. This literature focuses on the extent to which a given patent has been cited by subsequent patents, primarily as a metric for the fundamental importance of the disclosed invention to future innovators and innovations.[27] Tallies, types, and patterns of these so-called "forward citations" have been used by academics to measure the relative importance of various kinds of patents (such as those covering software[28] or those filed by universities[29] or lone inventors[30]),

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26. The defense of invalidity is raised in virtually every patent suit litigated in the United States. *See* Mark A. Lemley, *Rational Ignorance at the Patent Office*, 95 NW. U. L. REV. 1495, 1502 (2001) ("Virtually every patent infringement lawsuit includes a claim that the patent is either invalid or unenforceable due to inequitable conduct (or commonly both)."). In other countries, this is not always so. *See* Brian J. Love et al., *Patent Litigation in China: Protecting Rights or the Local Economy?*, 18 VAND. J. ENT. & TECH. L. 713, 736 (2016) (finding that less than 14 percent of invention patents enforced in China between 2006 and 2011 were challenged on validity grounds); Brian J. Love et al., *Patent Assertion Entities in Europe*, *in* PATENT ASSERTION ENTITIES AND COMPETITION POLICY 104, 112 (D. Daniel Sokol ed., 2017) (finding that "fewer than half of German and U.K. patent suits . . . included a validity challenge").

27. *See generally* Bronwyn H. Hall et al., *Market Value and Patent Citations*, 36 RAND J. ECON. 16, 16 (2005) (studying "the usefulness of patent citations as a measure of the 'importance' of a firm's patents, as indicated by the stock market valuation of the firm's intangible stock of knowledge"); ADAM B. JAFFE & MANUEL TRAJTENBERG, PATENTS, CITATIONS, AND INNOVATIONS: A WINDOW ON THE KNOWLEDGE ECONOMY (2002); Manuel Trajtenberg, *A Penny for Your Quotes: Patent Citations and the Value of Innovations*, 21 RAND J. ECON. 172 (1990).

28. *See* John R. Allison & Ronald J. Mann, *The Disputed Quality of Software Patents*, 85 WASH. U. L. REV. 297, 321 (2007); Josh Lerner et al., *Financial Patent Quality: Finance Patents After* State Street 16 (Harv. Bus. Sch., Working Paper No. 16-068, 2015).

29. *See* Bhaven N. Sampat et al., *Changes in University Patent Quality After*

to identify firms undervalued by the stock market,[31] to track the geographic or institutional flow of knowledge,[32] and even to predict the emergence of new technologies.[33] They have also given rise to numerous analytics firms that mine patent citation data in an attempt to rank or value patents.[34]

That said, citation-based patent rankings have been criticized as well. Commentators have noted many ways in which citation counts are biased and thus difficult to compare over time and across technologies.[35] In fact, there is reason to doubt that citation counts reliably measure what scholars have traditionally assumed that they do. Prior work suggests that technology users and researchers rarely read patents for their technical content.[36] And anecdotes abound of citation-related

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the Bayh–Dole Act: A Re-examination, 21 INT'L J. INDUS. ORG. 1371 (2003).

30. *See* Jasjit Singh & Lee Fleming, *Lone Inventors as Sources of Breakthroughs: Myth or Reality?*, 56 MGMT. SCI. 41 (2010).

31. *See* Mark Hirschey & Vernon J. Richardson, *Are Scientific Indicators of Patent Quality Useful to Investors?*, 11 J. EMP. FIN. 91 (2004); Anthony Breitzman & Patrick Thomas, *Using Patent Citation Analysis to Target/Value M&A Candidates*, 45 RES. TECH. MGMT. 28 (2002).

32. *See* Peter Thompson & Melanie Fox-Kean, *Patent Citations and the Geography of Knowledge Spillovers: A Reassessment*, 95 AM. ECON. REV. 450 (2005); Adam B. Jaffe & Manuel Trajtenberg, *Flows of Knowledge from Universities and Federal Laboratories: Modeling the Flow of Patent Citations over Time and Across Institutional and Geographic Boundaries*, 93 PROC. NAT'L ACAD. SCI. 12671 (1996); Adam B. Jaffe et al., *Geographic Localization of Knowledge Spillovers as Evidenced by Patent Citations*, 108 Q.J. ECON. 577 (1993).

33. *See* Peter Erdi et al., *Prediction of Emerging Technologies Based on Analysis of the US Patent Citation Network*, 95 SCIENTOMETRICS 225 (2013); Tugrul U. Daim et al., *Forecasting Emerging Technologies: Use of Bibliometrics and Patent Analysis*, 73 TECH. FORECASTING & SOC. CHANGE 981 (2006).

34. *See, e.g.*, *Quantitative Patent Scoring*, ACCLAIMIP, http://www.acclaimip.com/articles/quantitative-patent-scoring/ (last visited Aug. 10, 2017) [https://perma.cc/LC9K-3C2M]; *Models of Patent Valuation: White Paper*, CPA GLOBAL, https://www.cpaglobal.com/resources/wp_models-of-patent-valuation (last visited Aug. 8, 2018) [https://perma.cc/2PUV-8W5W]; *About PatentVector*, PATENTVECTOR, http://www.patentvector.com/about.php [https://perma.cc/VHR9-4SSV]; *Analytics Tools*, UNIFIED PATENTS, https://www.unifiedpatents.com (last visited Aug. 8, 2018) [https://perma.cc/NXC7-RXXY] ("Compare patent quality using APIX, CITX and BRIX ratings.").

35. *See* Jeffrey M. Kuhn et al., *Patent Citations Reexamined* (June 1, 2018) (unpublished manuscript), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2714954 [https://perma.cc/EJ8E-ESD4]; Nicolas van Zeebroeck, *The Puzzle of Patent Value Indicators*, 20 ECON. INNOVATION & NEW TECH. 33, 41 (2011) ("[C]itation counts are difficult to interpret by nature, due to their lack of natural scale . . . [which] makes citation counts difficult to compare across time and industries, where different scales in citation intensity have been observed.").

36. *See* Mark A. Lemley, *Ignoring Patents*, 2008 MICH. ST. L. REV. 19, 21 ("[R]esearchers and companies in component industries simply ignore patents.

gamesmanship by patentees, including to artificially inflate citations of their own patents.[37]

Another, related literature examines the characteristics of patents that their owners' actions reveal to be of relatively high or relatively low private value. Because direct evidence of the value parties place on patent rights is rarely made public,[38] scholars have traditionally studied proxies for value. For example, in one seminal study, Allison et al. compared the characteristics of patents selected for assertion in court to those not chosen.[39] Other scholars have studied instead, or in addition, the characteristics of patents that were and were not renewed by their owners in exchange for payment of periodic

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Virtually everyone does it. They do it at all stages of endeavor."). *But see* Lisa Larrimore Ouellette, *Who Reads Patents?*, 35 NATURE BIOTECH. 421, 421 (2017) (finding in a survey of scientific researchers that "[t]he vast majority of respondents had at least some experience reading patents, and just over half of the patent readers had read more than five patents in the past year").

37. Some companies, for example, frequently cite large numbers of their own prior patents in new applications. In addition, applicants may strategically decide to cite relatively few or many patents for a variety of reasons unrelated to the importance of the patented invention. *See* James H. Richardson, *Are Prior Art Citations Determinative of Patent Approval?: An Empirical Analysis of the Strategy behind Citing Prior Art*, 7 HASTINGS SCI. & TECH. L.J. 25 (2015).

38. *See* Lemley & Mhyrvold, *supra* note 2, at 257 (noting that "[e]ven if [a] patent or ones like it have been licensed dozens of times before, the terms of those licenses, including the price itself, will almost invariably be confidential"); Kelley, *supra* note 5, at 130 n.82 (noting that "[t]he vast majority of IP licenses and technology sales occur on confidential bases" and that "confidentiality is often highly negotiated between the parties"). Nonetheless, some licenses and sales become public when, for example, securities regulations require their disclosure. *See* SEC FORM 8-K, CURRENT REPORT PURSUANT TO SECTION 13 OR 15(D) OF THE SECURITIES EXCHANGE ACT OF 1934, at 4, Item 1.01, http://www.sec.gov/about/forms/form8-k.pdf [https://perma.cc/M7G9-U4L4] (requiring the disclosure of "material definitive agreement[s] not made in the ordinary course of business"); Thomas R. Varner, *An Economic Perspective on Patent Licensing Structure and Provisions*, 46 BUS. ECON. 229, 231 (2011) (studying 1,458 patent licenses and transfers disclosed to the SEC). Others are occasionally admitted into evidence in patent suits. *See* Tejas N. Narechania & Jackson Taylor Kirkland, *An Unsettling Development: The Use of Settlement-Related Evidence for Damages Determinations in Patent Litigation*, 2012 ILL. J.L. TECH. & POL'Y 1, 19–25 (collecting court orders discussing the discoverability and admissibility of licenses).

39. John R. Allison et al., *Valuable Patents*, 92 GEO. L.J. 435 (2004); *see also* Colleen V. Chien, *Predicting Patent Litigation*, 90 TEX. L. REV. 283 (2011); Alan Marco, *The Option Value of Patent Litigation: Theory and Evidence*, 14 REV. FIN. ECON. 323 (2005); Alan C. Marco & Richard D. Miller, *Patent Examination Quality and Litigation: Is There a Link?* (USPTO Econ., Working Paper No. 2017-09, 2017), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2995698 [https://perma.cc/SD33-WPN4].

maintenance fees.[40] And, more recently, a small number of studies have been conducted using actual pricing information gleaned from the secondary market for patents.[41]

Though nomenclature is not standardized in these lines of scholarship, we refer herein to the studies described above as studies of patent "value" because they most directly measure the correlation between patent characteristics and a patent's private and/or social value. While this link is rather obvious for maintenance fee payments and market prices, we believe it is also true for citation-based studies. Forward citations have long been viewed in the literature as a metric for measuring a patent's effectiveness at carrying out the patent system's fundamental social goal of publicizing important technical information,[42] and numerous studies have additionally suggested a strong, positive relationship between forward citations and a patent's realized or revealed private value.[43]

B. Patent Quality

In this paper, we study a different metric: the likelihood that a patent will survive a post-grant challenge to its validity. We refer to this as patent "quality."[44] While value and quality

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40. *See, e.g.*, James Bessen, *The Value of U.S. Patents by Owner and Patent Characteristics*, 37 RES. POL'Y 932 (2008); Yi Deng, *Renewal Study of European Patents: A Three-Country Comparison* (S. Methodist Univ., Dep't of Econ., Working Paper No. 0514, 2005), https://ideas.repec.org/p/smu/ecowpa/0514.html [https://perma.cc/3MPR-MFQL]; Dietmar Harhoff et al., *Citation Frequency and the Value of Patented Inventions*, 81 REV. ECON. STAT. 511 (1999); Jean O. Lanjouw et al., *How to Count Patents and Value Intellectual Property: The Uses of Patent Renewal and Application Data*, 46 J. INDUS. ECON. 405 (1998).

41. *See* Erik Oliver et al., *Finding the Best Patents—Forward Citation Analysis Still Wins*, IPWATCHDOG (Mar. 24, 2016), http://www.ipwatchdog.com/2016/03/24/finding-best-patents-forward-citation-analysis-still-wins/id=67192/ [https://perma.cc/86JY-L383]; Christina Odasso et al., *Selling Patents at Auction: An Empirical Analysis of Patent Value*, 24 INDUS. & CORP. CHANGE 417 (2014) (studying 535 lots auctioned by Ocean Tomo between 2006 and 2008); K. A. Sneed & D. K. N. Johnson, *Selling Ideas: The Determinants of Patent Value in an Auction Environment*, 39 R&D MGMT. 87, 89 (2008) (studying 121 Ocean Tomo lots resulting in 51 sales).

42. *See, e.g.*, Mann & Underweiser, *supra* note 20, at 3 ("The most advanced literature about patent quality . . . has analyzed the extent to which patents reflect and facilitate the diffusion of knowledge, as evidenced by citations to and in patents.").

43. *See* sources cited *supra* notes 39–41.

44. Here, we follow the lead of Mann and Underweiser. Mann & Underweiser, *supra* note 20, at 4 ("[T]his article conceives of quality as legal

are related, they are nonetheless distinct.

1. Quality vs. Value

The distinction is perhaps easiest to see in the context of social value. A patent's ability to disseminate detailed, groundbreaking, technical information to the public is conceptually unrelated to the validity of its claims. For example, an important disclosure may be accompanied by claims that are overbroad or even irrelevant. Few would doubt that Samuel Morse's patent on the telegraph was highly cited despite the fact that he famously claimed patent rights to "electromagnetism, however developed" for communicating "at any distances"[45]—a scope so broad that it would seemingly cover preexisting forms of communication using fires or lanterns,[46] as well as virtually every after-arising telecommunications technology. In fact, studies of patent citations have revealed that many highly cited patent applications are never issued at all.[47]

The distinction between quality and private value—i.e., value derived from the ability to enforce a patent—is a bit more

validity."); *see also* R. Polk Wagner, *Understanding Patent-Quality Mechanisms*, 157 U. PA. L. REV. 2135, 2138 (2009) ("Patent quality is the capacity of a granted patent to meet (or exceed) the statutory standards of patentability . . . ."); Bronwyn Hall et al., *Prospects for Improving U.S. Patent Quality via Postgrant Opposition*, 4 INNOVATION POL'Y & ECON. 115, 118 (2004) ("Both the economic and legal views suggest that high-quality patents describe an invention that is truly new, rather than an invention that is already in widespread use but not yet patented."). We caution, however, that others have used the term in a variety of contexts. *See* Mann & Underweiser, *supra* note 20, at 2 ("Because the term 'quality' is itself so general, it should not be surprising that different groups of scholars have used the term to examine distinct concepts relevant to their own interests.");. *see also Quality Metrics*, USPTO, https://www.uspto.gov/patent/initiatives/quality-metrics-1#step1 (last visited Dec. 8, 2017) [https://perma.cc/VBM9-MFV9] (including, among other things, metrics related to examination efficiency, grant rate consistency, and "stakeholder" perceptions); Christi J. Guerrini, *Defining Patent Quality*, 82 FORDHAM L. REV. 3091, 3091 (2014) (proposing that "patent quality" be examined "using a methodology applied in the business literature of quality management").

45. *See* O'Reilly v. Morse, 56 U.S. 62 (1854) (invalidating claim 8 of Morse's patent).

46. Light is, after all, part of the electromagnetic spectrum. *Electromagnetic Spectrum*, MERRIAM-WEBSTER'S COLLEGIATE DICTIONARY 401 (11th ed. 2003) (defining the term as "the entire range of wavelengths or frequencies of electromagnetic radiation extending from gamma rays to the longest radio waves and including visible light").

47. *See* van Zeebroeck, *supra* note 35, at 49 (reporting that "one fifth of the most cited applications have never been granted").

nuanced. Because a patentee generally must prove infringement *and* overcome an invalidity defense to win a patent suit, it stands to reason that patent quality is typically an integral component of patent value. But, while it is true that value and quality are theoretically related in this manner, it is less clear how well the two correlate in practice. For one, the "value" of a patent is a function of the value of the technology that it covers.[48] Thus, a low-quality patent that covers high-value technology may well have more "value" than a high-quality patent that covers low-value technology. At best, then, patent value is a noisy proxy for measuring the performance of the patent system.

Further, there is good reason to believe that in recent history, success in patent litigation (and thus patent value) has been influenced more by the breadth of a patent's claims than by the likelihood that those claims could withstand a full-throated validity challenge. For one, patents asserted in court are presumed to be valid,[49] and the validity of their claims must be disproved by the accused infringer with "clear and convincing" evidence.[50] What's more, a significant share of patent suits brought in the last two decades—perhaps even a majority—were filed by patentees with no intention of litigating to a decision on the merits. Each year since 2008, non-practicing entities (NPEs) have filed more than half of all U.S. patent infringement claims.[51] Because NPEs cannot be countersued for infringement and because U.S. courts rarely

48. Mann & Underweiser, *supra* note 20, at 4 ("[A] poorly drafted patent of dubious validity might be worth tens (or hundreds) of millions of dollars if it purports to claim rights to a valuable product (like the Blackberry or Microsoft Word). Conversely, a patent drafted with sterling clarity and undoubted novelty might be worth little or nothing if the product that it describes is unmarketable."); Marco, *supra* note 39, at 324 ("Thus, the value of a patent is a function of the enforceability of the property right, the underlying technology, and the distribution of beliefs about those parameters.").

49. 35 U.S.C. § 282(a) (2012) ("A patent shall be presumed valid. . . . The burden of establishing in-validity of a patent or any claim thereof shall rest on the party asserting such invalidity.").

50. Microsoft Corp. v. i4i Ltd. P'ship, 564 U.S. 91, 95 (2011) ("We consider whether [35 U.S.C.] § 282 requires an invalidity defense to be proved by clear and convincing evidence. We hold that it does.").

51. *See* Shawn P. Miller et al., *Introduction to the Stanford NPE Litigation Dataset*, STAN. L. SCH. (Oct. 23, 2017), https://law.stanford.edu/publications/introduction-to-the-stanford-npe-litigation-dataset/ (last visited Jan. 25, 2018) [https://perma.cc/7DPM-J4NX].

award fees to prevailing parties,[52] nonpracticing patentees are often able to leverage the high cost of patent litigation defense[53] to extract large settlements even in suits asserting patents that are likely invalid. Indeed, the Federal Trade Commission observed in a recent study of the licensing behavior of twenty-two PAEs (with 327 patent-asserting affiliates) that the majority of PAE suits settled quickly, generally within one year, and most often for amounts below the cost of defending the case to even a preliminary ruling on the merits.[54]

The primacy of claim breadth over validity is borne out by the secondary market as well. It has been reported that patent sales and prices are primarily driven by the scope of patent claims, not their validity.[55] For example, patents offered for sale are virtually never circulated to potential buyers along with prior art search reports but *are* frequently accompanied by "evidence of use" documentation suggesting that the patent may be infringed by one or more large tech companies.[56]

If it is true that a credible threat to sue has been, in recent memory, more important than a credible threat of winning, then it is likewise true that metrics of patent value and quality will often point in different directions. After all, broad claims are both more likely to cover an accused product and more likely to cover the prior art.

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52. *See* Thomas F. Cotter & John M. Golden, *Empirical Studies Relating to Patents—Remedies*, *in* RESEARCH HANDBOOK ON THE ECONOMICS OF INTELLECTUAL PROPERTY LAW (forthcoming 2018) (manuscript at 15–16 & n.71), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2665680 [https://perma.cc/6HT7-QRBS].

53. *See* AIPLA, 2017 REPORT OF THE ECONOMIC SURVEY I-142 (2017) (reporting that the median cost of defending a relatively small patent suit filed by an NPE (i.e., one with less than $1 million at stake) is $500,000).

54. *See* FED. TRADE COMM'N, PATENT ASSERTION ENTITY ACTIVITY 49 (Oct. 2016), https://www.ftc.gov/system/files/documents/reports/patent-assertion-entity-activity-ftc-study/p131203_patent_assertion_entity_activty_an_ftc_study_0.pdf [https://perma.cc/Q5QM-CFXZ] (reporting that lawsuits filed by "Litigation PAEs" generally "settled within a year of filing and . . . for less than $300,000").

55. It is our anecdotal experience that many large, sophisticated patent buyers select patents for purchase almost exclusively on the basis of the technology that they cover and the breadth of their claims.

56. *See* Love et al., *supra* note 2, at 380 (finding that "[p]ackages listed with EOUs were disproportionately likely to sell and, in addition, appear to have sold at a premium").

2. The Importance of Quality

In addition to theoretical and practical distinctions between patent value and quality, there are at least two more reasons why patent quality deserves additional attention from scholars of the patent system. First, studies of patent quality are more likely than studies of patent value to lead to actionable recommendations for improving the patent system. Factors that the literature tells us influence patent value are often outside the control of patent applicants and patent examiners. There is little a patent applicant can do at the time of filing to influence the value of the covered technology or the citation patterns of future inventors. The path of future innovation is notoriously difficult to predict.[57] As a result, studies of patent value are generally unable to make recommendations that patent system stakeholders can operationalize.

On the other hand, many suspected determinants of patent quality are very much within the ex ante control of applicants and examiners.[58] For example, patent prosecutors and examiners have long assumed a link between claim length and validity. This conventional wisdom is embodied in the so-called "pencil" and "hand" tests, which predict that patent claims that either can be covered by a pencil, or cannot be covered by one's hand, are unlikely to be both valid and infringed.[59] If studies like this one can identify where improvements can be made, patent applicants and examiners can likely adjust their procedures or habits to improve the quality of granted patents.

Second, the winds of change are blowing in U.S. patent law. Increasingly, validity is king when it comes to successful patent enforcement. Since the passage of the America Invents

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57. *See, e.g.*, THOMAS KUHN, THE STRUCTURE OF SCIENTIFIC REVOLUTIONS (4th ed. 2012) (conceptualizing the progress of science as one marked by occasional, sudden "paradigm shifts," rather than a linear progression driven by the gradual accumulation of information).

58. For a discussion of ways in which modifications to applicant behavior might be able to improve patent quality, see Stephen Yelderman, *Improving Patent Quality with Applicant Incentives*, 28 HARV. J.L. & TECH. 77 (2014). For a discussion of prior studies documenting variations in the behavior of patent examiners, see Ronald J. Mann, *The Idiosyncrasy of Patent Examiners: Effects of Experience and Attrition*, 92 TEX. L. REV. 2149 (2014).

59. *See, e.g.*, *The Hand Test Revisited*, IPCOPY (Nov. 15, 2012), https://ipcopy.wordpress.com/2012/11/15/the-hand-test-revisited/ [https://perma.cc/94CB-6FCH].

Act (AIA),[60] it has become more and more common for asserted patents' validity to be quickly challenged in administrative proceedings before the USPTO's Patent Trial and Appeal Board (PTAB).[61] Today, parties to a patent suit regularly receive at least a preliminary decision on claim validity from the PTAB before incurring the high cost of discovery, not to mention before the court conducts claim construction, rules on summary judgment motions, or holds a trial.[62] Increasingly, this is also true even for patents asserted by PAEs that are willing to settle for relatively small nuisance-value amounts. For example, in 2016, Unified Patents, Inc., (for which one of the authors of this Article works) challenged patents owned by Shipping and Transit, LLC, and Sportbrain Technologies, LLC,[63] that collectively had been asserted in well over two hundred lawsuits that settled on average within one hundred days of filing,[64] likely for relatively small amounts.[65] As a result, validity is more important than ever to the evaluation of patents, and we expect

60. Leahy-Smith America Invents Act, Pub. L. No. 112-29, 125 Stat. 284 (2011) (codified in various sections of Title 35).

61. *See, e.g.*, Erin Coe, *PTAB's Skyrocketing Petition Rate Starts to Stabilize*, LAW360 (Feb. 11, 2016), https://www.law360.com/articles/756867/ptab-s-skyrocketing-petition-rate-starts-to-stabilize [https://perma.cc/NTP9-6NKR] ("The Patent Trial and Appeal Board took in nearly 1,800 total petitions in 2015 for another record year as defendants in litigation continue to turn to the popular venue to wage validity fights over patents they are accused of infringing . . . .").

62. According to LexMachina.com, the median time to institution decision in an inter partes review is 187 days, Institution Decision Timing for PTAB Trials, LEX MACHINA, INC., https://lexmachina.com/ (search conducted Aug. 28, 2018) [https://perma.cc/ZS4A-JP66], while the median time to summary judgment in patent litigation is 663 days, Summary Judgment Timing for District Court Patent Cases, LEX MACHINA, INC., https://lexmachina.com/ (search conducted Aug. 28, 2018) [https://perma.cc/ZS4A-JP66].

63. *See Unified Challenges the Three Most Prolific Patent Trolls of 2016*, UNIFIED PATENTS (July 27, 2016), https://www.unifiedpatents.com/news/2016/7/27/unified-challenges-the-three-most-prolific-patent-trolls-of-2016 [https://perma.cc/83WR-N3CT].

64. Termination Timing for District Court Patent Cases for Party Group Shipping & Transit LLC and Sportbrain Technologies, LLC, LEX MACHINA, INC., https://lexmachina.com/ (search conducted Aug. 28, 2018) [https://perma.cc/ZS4A-JP66].

65. Shipping & Transit, LLC v. Hall Enters., Inc., No. CV 16-06535-AG-AFM, 27 WL 3485782, at *8 (C.D. Cal., July 5, 2017) ("Plaintiff's business model involves filing hundreds of patent infringement lawsuits, mostly against small companies, and leveraging the high cost of litigation to extract settlements for amounts less than $50,000."); Shipping & Transit, LLC v. Lensdiscounters.com, No. 16-80980-CIV, 2017 WL 5300068, at *5 (S.D. Fla., July 11, 2017) (noting in support of a fee award that plaintiff's "demand letter seeks payment of a $45,000 discounted 'license fee'" which is "indicative of a 'nuisance value settlement'").

this importance to increase as an ever-higher percentage of asserted patents are challenged before the PTAB.

3. Existing Studies of Quality

Despite the benefits that can be realized from studying the characteristics of high- and low-quality patents, scholars have paid the topic relatively little attention. Just a handful of existing studies attempt to measure the determinants of patent quality (defined as validity).

In what is probably the most important study of patent quality conducted to date, Mann and Underweiser studied the characteristics of 366 patents that were the subject of validity-related opinions issued by the U.S. Court of Appeals for the Federal Circuit between 2003 and 2009.[66] In a more recent contribution to the literature, Niidome performed a similar analysis for 267 patents challenged in post-grant proceedings conducted by the Japanese Patent Office.[67]

While both studies find a number of statistically significant differences between patents deemed valid and invalid, their small sample sizes cast doubt on their ability to adequately control for confounding factors like technology area and patent age. Perhaps as a result, the two studies' findings are somewhat at odds. For example, while Mann and Underweiser find significance in the number of office actions in a patent's prosecution history, as well as the number of citations that were added by the examiner during that process, Niidome finds no statistical significance in either characteristic.[68] Moreover, while both find significance in the number of technology classifications assigned by the patent office to an application, the effects they observe point in opposite directions.[69] Conflicts like these underscore the need for further research in this area.

In a second quality-related line of investigation, scholars—including Harhoff and Reitzig[70] and Graham et al.[71]—have

66. Mann & Underweiser, *supra* note 20, at 7.

67. Niidome, *supra* note 20, at 168–71.

68. *Compare* Mann & Underweiser, *supra* note 20, at 17, *with* Niidome, *supra* note 20, at 173.

69. *Compare* Mann & Underweiser, *supra* note 20, at 18 (finding that tech class count is a significant positive predictor of validity), *with* Niidome, *supra* note 20, at 175–76 (finding that IPC count is a significant negative predictor of validity).

70. Dietmar Harhoff & Markus Reitzig, *Determinants of Opposition Against*

studied the characteristics of patents challenged in EPO opposition proceedings and U.S. reexaminations. Though such studies benefit from much larger datasets, their relationship to "quality" is tangential at best because they do not incorporate data on actual validity determinations, only decisions to seek such determinations. As both studies readily admit, their findings suggest that challengers (quite rationally) select relatively "valuable" patents to challenge, but offer little in the way of predicting which valuable patents are valid or invalid.[72]

Finally, a third line of relevant scholarship analyzes the prosecution of patent families across multiple patent offices. Both Chien[73] and Lei and Wright[74] have examined the concurrent prosecution of related applications at the USPTO and EPO, with a particular focus on applications granted by the former but denied by the latter. These studies play an important role in benchmarking patent office procedures, but they are not without limitations. Perhaps most importantly, both studies measure quality by reference to ex parte examination rather than inter partes adjudication. Chien, for example, relies on the EPO's reputation as the "gold standard" for high-quality patent examination.[75] Though there is good reason to believe that the EPO does, in fact, provide higher-quality pros-

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EPO Patent Grants: The Case of Biotechnology and Pharmaceuticals, 22 INT'L J. INDUS. ORG. 443 (2004).

71. Stuart J.H. Graham et al., *Patent Quality Control: A Comparison of U.S. Patent Reexaminations and European Patent Oppositions*, *in* PATENTS IN THE KNOWLEDGE-BASED ECONOMY 74 (Wesley M. Cohen & Stephen A. Merrill eds., 2003).

72. Harhoff & Reitzig, *supra* note 70, at 443 ("We show empirically that the likelihood of opposition increases with patent value . . . ."); Graham et al., *supra* note 71, at 108 ("In general, the results from the regressions in columns (1) and (2) confirm the findings by Harhoff and Reitzig (2001) that variables positively correlated with the value of a patent increase the probability that the patent will be subject to opposition.").

73. Colleen V. Chien, *Comparative Patent Quality*, 50 ARIZ. ST. L.J. 71, 85 (2018) (comparing "USPTO and EPO patent application 'twins' filed in both jurisdictions in 2002").

74. Zhen Lei & Brian D. Wright, *Why Weak Patents? Testing the Examiner Ignorance Hypothesis*, 148 J. PUB. ECON. 43, 44 (2017) (studying "a set of US patents with a USPTO filing date between 1990 and 1995, for which applications were also filed in the Europe Patent Office (EPO) . . . [and] us[ing] outcomes from the EPO application process, reflecting not only European laws but also procedures and traditions distinct from those at the USPTO, as indirect indicators of the strength of the related US patents").

75. Chien, *supra* note 73, at 74 ("The . . . EPO . . . has come to be viewed by many as the 'gold standard' in patent quality.").

ecution than the USPTO, there is also good reason to believe that the EPO still routinely issues a large number of patents that would be invalidated if tested by litigants in court. For example, Henkel and Zischka estimate that a whopping 80 percent of German patents would be at least partially invalidated if challenged post grant.[76]

Overall, whether viewed individually or in the aggregate, these studies leave much to be desired. Studies that measure quality most directly and thoroughly suffer from small sample sizes. Conversely, studies with large samples rely on noisy quality metrics and compare only a handful of variables drawn from either the patent or its prosecution history (but not both). In this Article, we aim to assemble all the pieces of this puzzle: a large sample of patents, a reliable measure of quality, and a wide array of variables drawn from the patentee, the patent, and its prosecution history.

II. PATENT EXAMINATION AND POST-GRANT REVIEW

In order to analyze the determinants of patent quality, we must first understand how patents come to be, as well as the mechanisms available for testing their validity after issuance. In this Part we briefly summarize the procedures and policies that govern patent examination and post-grant validity challenges.

A. Patent Examination

Unlike most other forms of intellectual property, patent rights do not automatically vest at the moment of invention.[77] Rather, U.S. patent rights exist only when they are granted by the U.S. Patent and Trademark Office.[78] To obtain a patent, an

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76. Joachim Henkel & Hans Zischka, *Why Most Patents are Invalid: Extent, Reasons, and Potential Remedies of Patent Invalidity* 3 (TUM Sch. Mgmt. & Ctr. for Econ. Pol'y Res., Working Paper, June 12, 2015), https://www.tim.wi.tum.de/fileadmin/w00bcy/www/Research/Publications/Henkel/Henkel_Zischka_Patent_Validity.pdf [https://perma.cc/82VE-HQ7T] ("We conclude that around 80% or more of all active German patents are latently invalid, either fully or partially.").

77. *See, e.g.*, MARK A. LEMLEY ET AL., INTELLECTUAL PROPERTY IN THE NEW TECHNOLOGICAL AGE I-38 to I-41 (2016) (briefly describing each major type of intellectual property right).

78. *Id.* at I-38 ("To obtain a utility patent, an inventor must submit an application to the Patent and Trademark Office . . . .").

inventor must submit an application to the USPTO that includes a "specification" describing the invention and one or more "claims" that define the scope of protection sought.[79] Typically, these materials are prepared by a patent attorney or "agent" representing the applicant.[80] The application is then assigned to a patent "examiner" employed by the USPTO who is tasked with determining whether the application complies with all statutory requirements of patentability,[81] especially the requirement that all claims be novel and non-obvious.[82] If the examiner determines that the claims are overbroad relative to the body of pre-existing research—the "prior art"[83]—or relative to the information disclosed in the specification,[84] the examiner will "reject" the claims. Following a rejection, the applicant may amend the claims or replace them with entirely new versions and return them for a second look.[85] This back-and-forth process of rejections and responses generally plays out multiple times over the course of several years before any claims are issued in the form of an enforceable patent.[86] That

79. *See, e.g.*, ROBERT P. MERGES & JOHN F. DUFFY, PATENT LAW AND POLICY: CASES AND MATERIALS 28–32 (7th ed. 2017) (listing and describing the parts of a patent document).

80. *See, e.g.*, LEMLEY ET AL., *supra* note 77, at III-13.

81. *See, e.g.*, MERGES & DUFFY, *supra* note 79, at 60–62 (briefly summarizing the patent prosecution process).

82. *See* Quiang Lu et al., *USPTO Patent Prosecution Research Data: Unlocking Office Action Traits* 33 (USPTO Econ. Working Paper No. 2017-10, Nov. 2017), https://patentlyo.com/media/2017/11/USPTO-Patent-Prosecution-Research-Data_Unlocking-Office-Action-Traits-1.pdf [https://perma.cc/CE47-4NEM] (showing that obviousness and lack of novelty are the most frequent grounds for rejection in a sample of more than 4 million USPTO office actions issued between 2008 and 2017).

83. *See* 35 U.S.C. § 102(a)(1) (2012) (denying patent rights for inventions that were "patented, described in a printed publication, or in public use, on sale, or otherwise available to the public before the effective filing date of the claimed invention"); 35 U.S.C. § 103 (2012) (denying patent rights "if the differences between the claimed invention and the prior art are such that the claimed invention as a whole would have been obvious before the effective filing date of the claimed invention to a person having ordinary skill in the art to which the claimed invention pertains").

84. *See* 35 U.S.C. § 112(a) (2012) (denying patent rights for inventions that lack "a written description of the invention . . . in such full, clear, concise, and exact terms as to enable any person skilled in the art . . . to make and use the same").

85. *See, e.g.*, MERGES & DUFFY, *supra* note 79, at 60–62.

86. On average in recent years, patents have issued about three years after filing. *See* USPTO, TRADITIONAL TOTAL PENDENCY INCLUDING RCES, https://www.uspto.gov/corda/dashboards/patents/kpis/kpiWithRCE.kpixml [https://perma.cc/TGV0

said, applications that are pursued long enough overwhelmingly result in the issuance of at least one patent.[87]

As litigation outcomes attest,[88] examination of patent applications is an imperfect process.[89] To at least some extent, this is a rational choice on the part of patent policymakers.[90] As a practical matter, it is all but impossible for patent examiners to conclusively determine the novelty of the inventions that they examine. For example, doing so would require them to locate and review every relevant pre-existing discovery, no matter where in the world it was made or in what language it was documented.[91] And even if exhaustive examination were possible, it would rarely be cost-effective. About one-half of all issued U.S. patents expire prematurely because their owners fail to pay relatively modest maintenance fees that are due periodically after issue.[92] And whatever the case, history suggests that less than 2 percent of issued patents will ever be enforced

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-3E9A] (displaying monthly average pendency for patents issued between October 2015 and December 2017); USPTO, PENDENCY OF PATENT APPLICATIONS, https://developer.uspto.gov/visualization/pendency-patent-applications-2-visuals [https://perma.cc/U8C3-FUR7] (displaying monthly average pendency for patents issued between October 2008 and December 2015).

87. On average, about three-quarters of original U.S. patent applications result in at least one issued patent. Mark A. Lemley & Bhaven Sampat, *Is the Patent Office a Rubber Stamp?*, 58 EMORY L.J. 101, 102 (2008) (finding in a study of almost ten thousand U.S. patent applications filed in the month of January 2001 that "approximately 75% of all applications result in at least one patent").

88. *See,* Allison et al., *supra* note 8, at 1787.

89. *See*, *e.g.*, Henkel & Zischka, *supra* note 76, at 3.

90. *See* Lemley, *supra* note 26, at 1497 ("Because so few patents are ever asserted against a competitor, it is much cheaper for society to make detailed validity determinations in those few cases than to invest additional resources examining patents that will never be heard from again. In short, the PTO doesn't do a very detailed job of examining patents, but we probably don't want it to.").

91. Under U.S. law, a patent claim lacks novelty if, among other things, the invention it claims was disclosed in any prior art "publication" made anywhere else in the world. *See* 35 U.S.C. § 102 (2012). Courts have also broadly defined the concept of "publication" to include documents available in public libraries and even presentations made at conferences. *In re* Klopfenstein, 380 F.3d 1345, 1350–52 (Fed. Cir. 2004) (holding that a slide presentation on a poster presented at a conference may constitute an invalidating "printed publication"). Thus, for example, a U.S. patent claim can be invalidated by a single copy of a doctoral thesis that was written in German and is available only in a German library. *In re* Hall, 781 F.2d 897 (Fed. Cir. 1986).

92. *See, e.g.*, Dennis Crouch, *Maintenance Fees 2015*, PATENTLY-O (July 21, 2015), http://patentlyo.com/patent/2015/07/maintenance-fees-2015.html [https://perma.cc/5SNJ-2TAS] (showing that only 40 to 50 percent of patentees elect to take advantage of the full patent term by making all three maintenance fee payments required by the USPTO).

in court.[93]

B. High Costs from Low-Quality Patents

Since any given patent is likely to languish in obscurity until expiration, the USPTO's decision not to conduct scorched-earth examination is a rational one. That said, there is good reason to believe that patent examination is presently conducted in a manner that is too cost conscious.[94] U.S. patent examiners, for example, work under a quota system that requires them to review applications quickly,[95] devoting on average less than twenty hours total per application.[96] Moreover, studies find that examiners largely limit their search for prior art to indexed databases of published patents, often thereby ignoring the academic literature, books, and other sources published exclusively online.[97]

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93. *See, e.g.*, Lemley, *supra* note 26, at 1502 ("[I]t is reasonable to estimate that at most only about two percent of all patents are ever litigated, and less than two-tenths of one percent of all issued patents actually go to court.").

94. *See, e.g.*, Lei & Wright, *supra* note 74, at 43 ("Among lawyers, economists, policy makers and businessmen there is a widespread belief that patent examiners at the United States Patent Office (USPTO) have allowed the grant of too many patents that do not satisfy the statutory criteria for allowance. Such 'weak patents' impose social costs associated with increased uncertainty and abusive litigation without commensurate social benefits associated with increased innovation incentives.").

95. *See, e.g.*, Michael D. Frakes & Melissa F. Wasserman, *Is the Time Allocated to Review Patent Applications Inducing Examiners to Grant Invalid Patents? Evidence from Micro-Level Application Data*, 99 REV. ECON. & STATS. 550, 552 (2016) (explaining that the USPTO's time-per-application expectation "depends on both the technological field in which the examiner is working and her position in the general schedule (GS) pay scale").

96. *See id.* ("On average, a U.S. patent examiner spends only nineteen hours reviewing an application: reading the application, searching for prior art, comparing the prior art with the application, writing a rejection, responding to the patent applicant's arguments, and often conducting an interview with the applicant's attorney." (internal citation omitted)); *see also* Lemley, *supra* note 26, at 1500 (estimating eighteen hours of examiner time per application); FED. TRADE COMM'N, TO PROMOTE INNOVATION: THE PROPER BALANCE OF COMPETITION AND PATENT LAW AND POLICY, Ch. 5, at 5 (Oct. 2003), https://www.ftc.gov/reports/promote-innovation-proper-balance-competition-patent-law-policy [https://perma.cc/PAZ3-JR4Q] (collecting estimates, including "24.9 hours at the outside, but often half that; 21 hours; 20 to 25 hours; 18 hours; 8-18 hours; and more than 11-12, but 'not a lot of hours' to read and understand the application, search for prior art, evaluate patentability, communicate with the applicant, work out necessary revisions, and reach and write up conclusions").

97. *See* Christopher A. Cotropia et al., *Do Applicant Patent Citations Matter?*, 42 RES. POL'Y 844, 844 (2013) (finding "patent examiners rarely use applicant-

The result, many contend, is a proliferation of low-quality patents that impose large costs on innovators and, on balance, act to slow rather than spur the overall pace of innovation.[98] One reason for this concern is the possibility that the issuance of low-quality patents will beget even more low-quality patents, and so on in a vicious cycle.[99] This may happen for at least two reasons: First, patenting firms may feel compelled to seek more patent protection in response to a perceived decline in patent quality in order to raise the odds that their inventions are adequately protected.[100] Second, an increase in patent filing rates may, in turn, increase strain on already-overburdened examiners, inducing them to spread limited examination resources thinner still and, as a consequence, issue patents of even lower quality.[101]

Regardless of their *raison d'etre*, patents of questionable validity can impose significant costs on actors in the world of innovation who, in the absence of relatively inexpensive methods for testing patent validity, may often find it rational to license patents that, if challenged, would be invalidated with high probability.[102] Other times, researchers may decide not to use the patented technology at all.[103] In addition to slowing the pace of research and development for existing incumbents,

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submitted art in their rejections to narrow patents, relying almost exclusively on prior art they find themselves").

98. *See* sources cited *supra* notes 10–12.

99. *See* Hall & Harhoff, *supra* note 10, at 993–94 ("The issuance of low quality patents is also likely to spur significant increases in patent applications, further straining the already overburdened examination processes of the USPTO. A vicious circle may result, in which cursory examinations of patent applications result in the issue of low quality patents, which triggers rapid growth in applications, further taxing the limited resources of the USPTO, further limiting the examination of individual applications, and further degrading the quality of patents.").

100. *See id.* at 993 ("[T]he issue of a large number of low quality patents will increase uncertainty among inventors concerning the level of protection enjoyed by these related inventions . . . .").

101. *See id.* at 993–94.

102. *See id.* at 993 ("[R]esolution of the non-producer's claims is clearly more costly when the validity and breadth of the asserted patent can only be determined via expensive litigation. In that instance, paying licensing fees may be cheaper than going to court, even if the patent in question is viewed as low quality by the accused infringer.").

103. *See id.* ("If . . . previous technical advances are covered by patents of dubious validity or uncertain breadth, the costs to inventors of pursuing the inventions that rely on them may be so high as to discourage such cumulative invention.").

inefficiencies like these can quash entirely new endeavors. A bulwark of accumulated low-quality patents can both deter entrepreneurs from entering a market in the first place[104] and discourage the combination of complementary technologies to produce new goods or services.[105]

C. Post-Grant Validity Challenges

To mitigate the costs of imperfect examination, patent systems generally allow the public to challenge the validity of granted patent claims. Most often, these post-grant challenges are made by companies that have been sued for patent infringement because accused infringers can, and generally do, argue that the asserted patent is "invalid" and, thus, never should have been granted. In the United States, the defense of invalidity is pled in virtually every patent suit, and defendants are successful in at least partially invalidating an asserted patent about 40 percent of the time when validity is litigated to a decision on the merits.[106]

However, despite the relatively high rate of success, validity decisions are rare in court cases. In a study of more than five thousand patent suits filed in 2008 and 2009, Allison et al. found just 430 decisions concerning the validity of asserted patents.[107] One reason for the dearth of rulings is the simple fact that litigation is expensive, and defending patent suits is among its most expensive forms. According to a recent survey conducted by the American Intellectual Property Law Association, the cost of defending a U.S. patent suit to the point where a ruling on the merits might be possible generally exceeds $250,000, even for cases with less than $1 million in potential damages at stake.[108] Accordingly, many accused infringers rationally choose to settle cases enforcing likely invalid patents simply to avoid the high cost of defense, particularly in countries like the United States where attorney's fee

104. *See* Lerner, *supra* note 11, at 489–90.
105. *See* Heller & Eisenberg, *supra* note 12.
106. Allison et al., *supra* note 8, at 1787.
107. *Id.*
108. *See* AIPLA, *supra* note 53, at I-118 (reporting a median cost of $250,000 (and an average of $306,000) for litigating a patent case with less than $1 million at stake through discovery and claim construction).

awards are rare.[109] This fact makes it possible for unscrupulous patentees to enforce weak patents in order to extract nuisance-value settlements from companies active in the product market,[110] a practice sometimes referred to as patent "trolling."

In addition, even in the context of good-faith patent assertion, an individual defendant has suboptimal incentives to challenge the validity of the asserted patent because it will bear the full cost of defense but share the benefit of invalidation with all its competitors.[111] In fact, there is good reason to believe that defendants sometimes tacitly collude with patent enforcers to buttress the subsequent assertion of the same patent against the defendants' competitors.[112]

One way to increase the likelihood that invalid patents will be eliminated post-grant is to establish alternative mechanisms for testing the validity of issued patents that are less expensive and more broadly available than judicial challenges. One alternative available today in many nations is some form of administrative patent review undertaken by the country's patent office. In the United States, issued patents can be challenged in court or in one of a variety of "post-grant proceedings," and in some countries like China and Germany, administrative review is the exclusive means for challenging the validity of issued patents.[113]

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109. *See* Colleen V. Chien et al., *Enhanced Damages, Litigation Cost Recovery, & Interest*, *in* PATENTS REMEDIES AND COMPLEX PRODUCTS: TOWARD A GLOBAL CONSENSUS 158, 185–91 (Brad Biddle, Jorge L. Contreras, Brian J. Love, & Norman V. Siebrasse, eds., forthcoming) (describing regimes for attorney fee and litigation cost recovery in Europe, Asia, and the United States).

110. *See* FED. TRADE COMM'N, *supra* note 19, at 4–5.

111. *See* Joseph Farrell & Robert P. Merges, *Incentives to Challenge and Defend Patents: Why Litigation Won't Reliably Fix Patent Office Errors and Why Administrative Patent Review Might Help*, 19 BERKELEY TECH. L.J. 943, 952 (2004) ("[F]or instance, if there are five infringers of equal size, each gets only a fifth of the gains from a successful challenge because each is paying only a fifth of the patentee's total royalties. Therefore, the patentee has five times more incentive to prevail in litigation than any one challenger has.").

112. It is common for repeat patent enforcers to begin assertion campaigns against relatively small, weak defendants in hopes of obtaining favorable settlements or court victories that will set an initial "market price" for a license moving forward. *See* Brian J. Love & James C. Yoon, *Expanding Patent Law's Customer Suit Exception*, 93 B.U. L. REV. 1605, 1635 (2013). Initial defendants are often complicit in this process and, for example, may willingly settle for an artificially high royalty rate applied to an artificially small quantity of sales in hopes that their competitors will later pay the same rate on all their revenue. *See id*.

113. For a summary of the procedures for post-grant challenges available in

In one form or another, post-grant administrative review has been available in the United States since 1981, when a procedure called "ex parte reexamination" was established to allow the public to "petition" the USPTO to cancel one or more claims of an issued patent and re-open the examination process between the USPTO and patentee.[114] A second procedure, dubbed "inter partes reexamination," was added in 1999 to give petitioners the option of participating in the subsequent examination process.[115]

In the years that followed, however, petitions for inter partes reexamination were filed relatively rarely and ex parte reexamination was seldom used successfully to eliminate problematic claims,[116] leading to a widespread perception that neither procedure provided an efficient alternative to defending an infringement suit in court.[117] In 2011, Congress responded by

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Germany and China, see Katrin Cremers et al., *Invalid but Infringed? An Analysis of the Bifurcated Patent Litigation System*, 131 J. ECON. BEHAV. & ORG. 218, 221–22 (2016) (describing Germany's bifurcation of decisions regarding infringement, which are heard by regional courts, and challenges to validity, which are heard by the German Federal Patent Court); Brian J. Love et al., *Patent Litigation in China: Protecting Rights or the Local Economy?*, 18 VAND. J. ENT. & TECH. L. 713, 721–22 (2016) (describing China's bifurcation of decisions regarding infringement, which are typically heard by Intermediate People's Courts, and validity challenges, which are heard by SIPO's Patent Review and Adjudication Board).

114. *See* MPEP § 2209 (9th ed. Rev. Aug. 2017) ("Procedures for reexamination of issued patents began on July 1, 1981, the date when the reexamination provisions of Public Law 96-517 came into effect.").

115. *Id.* § 2609 ("The inter partes reexamination statute and rules permit any third party requester to request . . . inter partes reexamination of a patent which issued from an original application filed on or after November 29, 1999 . . . .").

116. Overall, about 87 percent of patents challenged in ex parte reexamination survived, and two-thirds were re-issued with new claims. USPTO, EX PARTE REEXAMINATION FILING DATA 2 (Sept. 30, 2017) [hereinafter USPTO, EXPARTE REEXAMINATION FILING DATA], https://www.uspto.gov/sites/default/files/documents/ex_parte_historical_stats_roll_up.pdf [https://perma.cc/463H-FKL8]. As a result, ex parte reexamination was often used strategically by patentees to re-write their own issued claims before asserting them. *Id.* (reporting that 29 percent of ex parte reexaminations were filed by the challenged patent's owner).

117. *See* Brian J. Love & Shawn Ambwani, *Inter Partes Review: An Early Look at the Numbers*, 81 U. CHI. L. REV. DIALOGUE 93, 95 (2014) ("Though originally developed to serve as a cost-effective alternative to full-blown litigation, reexaminations rarely realized that goal. Rather, reexamination developed a well-deserved reputation for lengthy delays, a lack of decisive results, and a permissiveness for claim amendments that led some in the patent bar to view reexamination more as a vehicle for patentees to strengthen their patent rights post hoc than as a tool for possible infringers to quickly and cheaply eliminate invalid claims without resorting to litigation.").

passing legislation overhauling the USPTO's system for post-grant review. While ex parte reexamination was left unchanged, the America Invents Act (AIA) replaced inter partes reexamination with a suite of three new procedures for the administrative review of issued patent claims.[118]

D. Inter Partes Review

Principal among the new procedures is inter partes review (IPR), which has proven to be far more popular than both its predecessors and contemporaries. Since it became available in September 2012, parties have filed almost 6,500 petitions for IPR, a figure that exceeds the total number of patent cases filed in all but one district court during the same period of time,[119] as well as the total number of petitions for inter partes reexamination that were filed during the thirteen years that the process was available.[120] Relatively speaking, the two other new forms of administrative challenge created by the AIA—"post-grant review" (PGR) and "covered business method patent" (CBM) review—have been used infrequently, due in large measure to greater restrictions on their availability. Post-grant reviews must be filed within nine months of a patents' issuance[121] and are applicable only to patents with priority dates

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118. Pub. L. No. 112-29, 125 Stat. 284 (2011) (codified at 28 U.S.C. § 1454; 35 U.S.C. §§ 123, 257, 298–99, 321–29 (2012)).

119. According to LexMachina.com, 8,414 patent suits were filed in the U.S. District Court for the Eastern District of Texas between September 16, 2012 and the end of 2017. Courts Summary for District Court Patent Cases Filed Sept. 16, 2012–Dec. 31, 2017, LEX MACHINA, INC., https://lexmachina.com/ (search conducted Aug. 28, 2018) [https://perma.cc/ZS4A-JP66]. The next most popular district, the District of Delaware, saw just 4,506 patent suits during the same period. *Id.*

120. A total of 1,919 petitions for inter partes reexamination were filed between 1999 and 2012, an average of fewer than 13 per month. USPTO, INTER PARTES REEXAMINATION FILING DATA (Sept. 30, 2017) [hereinafter USPTO, INTER PARTES REEXAMINATION FILING DATA], https://www.uspto.gov/sites/default/files/documents/inter_parte_historical_stats_roll_up.pdf [https://perma.cc/L827-PUTC]. Less than 14,000 petitions for ex parte reexamination have been filed since 1981, an average of about 32 per month. USPTO, EXPARTE REEXAMINATION FILING DATA, *supra* note 116. In recent years, petitions for review by the PTAB have been filed at a rate of approximately 150 per month. *See, e.g.*, *2017 Patent Dispute Report: Year in Review*, UNIFIED PATENTS, INC. (Dec. 30, 2017), https://www.unifiedpatents.com/news/2017/12/26/2017-patent-dispute-report-year-in-review [https://perma.cc/EC3M-XPKW] (reporting that an average of 449 petitions per quarter were filed in 2017).

121. 35 U.S.C. § 321(c) (2012) ("A petition for a post-grant review may only be

on or after March 16, 2013. To date, fewer than one hundred PGRs have been filed.[122] Covered business method patent reviews, as their name suggests, apply only to patents that claim a "business method"—that is, "a method or corresponding apparatus for performing data processing or other operations used in the practice, administration, or management of a financial product or service"[123]—and must be filed by a party with standing to challenge the patent in court.[124] About five hundred petitions for CBM review have been filed to date, and the pace of filings is falling.[125] IPRs, by contrast, may be filed against any patent that is more than nine months old and may be filed by any party, whether or not they have been sued or threatened with suit.[126]

Compared to its predecessors, IPR proceeds much more quickly and ends with greater finality. Unlike reexaminations, which merely initiated yet another opened-ended examination of the challenged claims by USPTO examiners, IPRs take place on a tight schedule and are decided by Administrative Patent Judges (APJs) sitting on the Patent Trial and Appeal Board (PTAB). The AIA mandates that the PTAB must decide whether to grant—or "institute"—a petition within six months of filing,[127] and if a petition is instituted the PTAB must issue a final decision on the patentability of the challenged claims within one year of the institution decision.[128] The result is a decision that is not only much faster than inter partes

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filed not later than the date that is 9 months after the date of the grant of the patent . . . .").

122. Case Search for Type of Pleading "Petition for Post Grant Review," DOCKET NAVIGATOR, INC., https://www.docketnavigator.com/ (search conducted Aug. 1, 2017) [https://perma.cc/YB3V-W23G].

123. 37 C.F.R. § 42.301(a) (2017).

124. *Id.* § 42.302(a) (2017) ("A petitioner may not file with the Office a petition to institute a covered business method patent review of the patent unless the petitioner . . . has been sued for infringement of the patent or . . . . a real and substantial controversy regarding infringement of a covered business method patent exists such that the petitioner would have standing to bring a declaratory judgment action in Federal court.").

125. Case Search for Type of Pleading "Petition for Covered Business Method," DOCKET NAVIGATOR, INC., https://www.docketnavigator.com/ (search conducted Aug. 1, 2017) [https://perma.cc/YB3V-W23G].

126. *See, e.g.*, USPTO, MAJOR DIFFERENCES BETWEEN IPR, PGR, AND CBM, https://www.uspto.gov/sites/default/files/ip/boards/bpai/aia_trial_comparison_chart.pptx [https://perma.cc/QK37-RJ63].

127. 35 U.S.C. § 314(b) (2012).

128. *Id.* § 316(a)(11) (2012).

reexamination, which had a median time to termination of about three years,[129] but also far faster than is typically possible in court, where trials take place on average well over two years after the filing of an infringement complaint.[130]

Compared to reexamination, IPRs also offer petitioners a higher likelihood of finality. Patentees facing reexamination were permitted to amend their claims as a matter of course, and as a result, the most common outcome of a reexamination was the issuance of a new set of amended claims that could be asserted against the petitioner.[131] Though claim amendments are technically permitted in IPRs, to date the PTAB has denied all but a handful of motions to amend.[132] Moreover, when petitions for IPR are litigated to a decision on the merits, the PTAB has frequently elected to review and cancel all challenged claims, leaving nothing behind for the patentee to subsequently assert.[133] On the flip side, when claims are upheld, patentees also benefit from a broad estoppel provision that prevents challengers from raising the same invalidity arguments again in court.[134] As a result, IPR often operates as a one-time "up or down" vote on the validity of challenged claims.

1. Procedural Overview

IPR includes a first round of briefing and a decision from the Board on whether to institute the petition, followed by a second round of briefing, a hearing, and finally a decision from the Board on the patentability of challenged claims. First, a

129. USPTO, INTER PARTES REEXAMINATION FILING DATA, *supra* note 120.

130. According to LexMachina.com, the median time-to-trial for patent cases filed between 2000 and 2016 is 821 days. Trial Timing for District Court Patent Cases Filed 2000-2016, LEX MACHINA, INC., https://lexmachina.com/ (search conducted Aug. 28, 2018) [https://perma.cc/ZS4A-JP66].

131. USPTO, INTER PARTES REEXAMINATION FILING DATA, *supra* note 120; USPTO, EX PARTE REEXAMINATION FILING DATA, *supra* note 116.

132. Trial Resolutions for PTAB Trials, LEX MACHINA, INC., https://lex machina.com/ (search conducted Aug. 28, 2018) [https://perma.cc/ZS4A-JP66].

133. *See Analytics: Cases by Status and Phase*, UNIFIED PATENTS, INC., https://portal.unifiedpatents.com/ptab/analytics/case-level/by-status-and-phase (last visited Jan. 13, 2018) [https://perma.cc/HDG2-PRW5].

134. 35 U.S.C. § 315(e)(2) (2012) ("The petitioner in an inter partes review of a claim in a patent . . . that results in a final written decision . . . may not assert either in a civil action . . . that the claim is invalid on any ground that the petitioner raised or reasonably could have raised during that inter partes review.").

party wishing to challenge a patent must file a petition that establishes a "reasonable likelihood" of invalidating at least one of the patent's claims.[135] As with reexamination, petitions are limited to arguments that the patent is invalid for lack of novelty, or as obvious in light of prior patents or other "printed publications."[136] Once a petition is filed, the owner of the challenged patent is given three months to prepare and file a "preliminary response," but the patentee is not required to do so.[137]

The patent owner is free to end the review at any time by unilaterally canceling its challenged (or, later, instituted) claims. Likewise, the parties are also free to settle on confidential terms at any time,[138] and to date about one-third of IPRs have concluded with a settlement.[139] The PTAB has discretion to proceed with its determination of validity despite a settlement, but in practice, it has done so very rarely.[140]

By statute, the PTAB must issue a decision within six months of the petition's filing as to whether the petitioner has shown a reasonable likelihood of success.[141] If the petitioner has met that burden for at least one challenged claim, the review is considered instituted and continues.[142] Institution decisions are final and nonappealable.[143]

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135. 35 U.S.C. § 314(a) (2012) ("The Director may not authorize an inter partes review to be instituted unless the Director determines that . . . there is a reasonable likelihood that the petitioner would prevail with respect to at least 1 of the claims challenged in the petition."); 37 C.F.R. § 42.108(c) (2017).

136. 35 U.S.C. § 311(b) (2012) ("A petitioner in an inter partes review may request to cancel as unpatentable 1 or more claims of a patent only on a ground that could be raised under section 102 or 103 and only on the basis of prior art consisting of patents or printed publications.").

137. 35 U.S.C. § 313 (2012); 37 C.F.R. § 42.107 (2017).

138. 35 U.S.C. § 317 (2012); 37 C.F.R. § 42.74 (2017).

139. *Analytics: Cases by Status and Phase*, *supra* note 133.

140. *See* Stephen Kenney, *When Joint Settlement Agreements Do Not Settle*, PTAB BLOG (Oct. 20, 2015), http://www.ptab-blog.com/2015/10/20/when-joint-settlement-agreements-do-not-settle/ [https://perma.cc/C4K7-KLBM] ("Under 37 CFR 42.74, parties to a trial before the Patent Trial and Appeal Board (PTAB) may mutually agree to terminate the proceeding. However, the PTAB is not a party to the settlement and . . . in select instances the PTAB has elected to continue the proceeding despite a joint motion to terminate by the Parties.").

141. 35 U.S.C. § 314(b) (2012); 37 C.F.R. §42.107(b) (2017).

142. *See infra* note 146. Prior to *SAS Institute, Inc. v. Iancu*, 138 S. Ct. 1348 (2018), the PTAB would proceed to a final written decision only with respect to those claims that it deemed likely invalid at the institution stage. Today, the PTAB must issue "a final written decision addressing all of the claims . . . challenged" in the petition. *Id.* at 1359.

143. *See* 35 U.S.C. § 314(d) (2012) ("The determination by the Director [of the

At this point, if the challenged patent has been asserted in court, it is common for the petitioner to request that litigation be stayed pending the review's final outcome.[144] District courts have broad discretion to stay the cases before them in the interests of efficiency, including to await the resolution of independent proceedings, like IPRs.[145] Post-institution, courts are generally receptive to such motions and grant them roughly 80 percent of the time, though grant rates vary significantly from district to district.[146] Some courts are additionally receptive to motions to stay suits filed against other accused infringers in addition to the suit filed against the successful petitioner.[147] To similar effect, in situations where an instituted patent has been asserted against numerous parties, it is also common for other defendants to file copy-cat petitions that substantially crib from the one that was just instituted.[148]

Patent Office] whether to institute an inter partes review under this section shall be final and non-appealable."); Cuozzo Speed Techs., LLC v. Lee, 136 S. Ct. 2131, 2136 (2016) (holding that section 314 "may not bar consideration of a constitutional question" but nonetheless "does bar judicial review of the kind of mine-run claim at issue here, involving the Patent Office's decision to institute inter partes review").

144. According to Docket Navigator, to date, courts have decided over 1,650 motions to stay pending inter partes review. Document Search for "Motion to Stay Pending Inter Partes Review," DOCKET NAVIGATOR, INC., https://www.docketnavigator.com/ (search conducted Aug. 28, 2018) [https://perma.cc/YB3V-W23G].

145. *See, e.g.*, Landis v. N. Am. Co., 299 U.S. 248, 254–55 (1936) ("[T]he power to stay proceedings is incidental to the power inherent in every court to control the disposition of the causes on its docket with economy of time and effort for itself, for counsel, and for litigants. How this can best be done calls for the exercise of judgment, which must weigh competing interests and maintain an even balance.").

146. In cases between the same parties to the IPR, grant rates are especially high when motions are filed after the IPR is instituted. *See* Love & Ambwani, *supra* note 117, at 103 ("Of patent suits proceeding in parallel with an instituted IPR between the same parties, a motion to stay was filed in over 76 percent. Overall, these cases were stayed (at least in part) 82 percent of the time, though rates varied considerably across districts."). Overall, including motions filed by other parties in other cases, as well as motions filed by the petitioner pre-institution, the grant rate is a bit more modest. DocketNavigator.com reports an overall grant rate of about 69 percent for motions to stay pending inter partes review.

147. *See* Brian J. Love, *Inter Partes Review as a Shield for Technology Purchasers: A Response to Gaia Bernstein's* The Rise of the End-User in Patent Litigation, 56 B.C. L. REV. 1075, 1089–90 (2015) (explaining that "manufacturers [have been] relatively successful in leveraging the IPR process to halt litigation filed against their customers" and providing examples).

148. *See, e.g.*, *IPRs: Balancing Effectiveness vs. Cost*, RPX (June 17, 2016), https://www.rpxcorp.com/2016/06/17/iprs-balancing-effectiveness-vs-cost/ [https://

Overwhelmingly, these "me too" petitions are quickly instituted and joined to the original.[149]

Again by statute, the PTAB must issue a final written decision within one year of the institution decision and, thus, within a total of eighteen months from the date of petition.[150] By contrast, a litigant is unlikely to get a substantive ruling on validity from a court for several additional months,[151] and often not until much, much later. Immediately following institution, the patent owner is allotted three months to conduct discovery and file a post-institution response to the petition and a motion to amend.[152] Afterwards, the petitioner is given three months to conduct its own discovery and file a reply.[153] Finally, the patent owner may conduct one more month of discovery and file a sur-reply of its own.[154]

The petitioner may also file a motion to amend the challenged claims at the time of its response.[155] However, unlike in reexamination where amendments were permitted as a matter of course, motions to amend in inter partes reviews have been granted only a handful of times[156] and, for all practical purposes, are de facto prohibited.

IPRs culminate in oral hearings held before a panel of

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perma.cc/8UEE-X7G2] (noting that "some petitioners use a 'copycat' strategy, filing a petition that lifts the arguments from an existing IPR that the new petitioner then seeks to join").

149. According to DocketNavigator.com, the PTAB has granted over 80 percent of motions for joinder or consolidation of challenges. Document Search for "PTAB Motion to Consolidate, OR PTAB Motion for Joinder," DOCKET NAVIGATOR, INC., https://www.docketnavigator.com/ (search conducted Aug. 28, 2018) [https://perma.cc/YB3V-W23G].

150. *See* sources cited *supra* notes 127–128.

151. According to LexMachina.com, the median time to summary judgement in patent cases filed since 2000 is about 660 days. Summary Judgment Timing for District Court Patent Cases, LEX MACHINA, INC., https://lexmachina.com/ (search conducted Aug. 28, 2018) [https://perma.cc/ZS4A-JP66].

152. 37 C.F.R. § 42.120 (2017).

153. *See, e.g.*, USPTO, TRIALS, https://www.uspto.gov/patents-application-process/patent-trial-and-appeal-board/trials (last visited Jan. 22, 2018) [https://perma.cc/FGX5-YWWR] (showing a timeline of PTAB trial deadlines).

154. *Id.*

155. 37 C.F.R. § 42.121 (2017).

156. *See* USPTO, PATENT TRIAL AND APPEAL BOARD MOTION TO AMEND STUDY 4–6 (2017), https://www.uspto.gov/sites/default/files/documents/PTAB%20MTA%20Study%20%203%20%20update%20through%2020170930.pdf [https://perma.cc/WM7W-NUVB] (reporting that as of September 30, 2017 motions to amend were filed in just 8 percent of all PTAB challenges and that only fourteen total motions to amended have been granted in whole or in part).

three APJs. Though often called "trials," these hearings do not include live testimony and share much more in common with appellate arguments than trials. Sometime after the hearing—typically just before the statutory deadline—the panel will issue a final written decision on the validity of the instituted claims.[157] Final written decisions may be appealed to the U.S. Court of Appeals for the Federal Circuit,[158] but appeals from the PTAB are reviewed with deference to the Board's decisions and are affirmed across the board at very high rates (about three-quarters of the time to date).[159]

If any instituted claims survive review, the petitioner is thereafter estopped from challenging them again in court on grounds that the petitioner raised "or reasonably could have raised" in the IPR.[160] Though written in broad terms, the IPR estoppel provision does not completely prohibit unsuccessful petitioners from challenging the validity of surviving claims in subsequent litigation. For one, estoppel applies only to arguments based on evidence that is admissible in an IPR—that is, prior art publications.[161] Thus, a petitioner may still argue in court that surviving patent claims lack novelty or are obvious in light of prior public sales or uses rather than publications. In addition, an unsuccessful petitioner may raise in court a number of other bases for invalidity, including failure to satisfy the "utility," "written description," or "enablement" requirements.[162] Nonetheless, due to the effect of estoppel, petitioners that fear (or are currently facing) assertion of the challenged patent in court have a strong incentive to take their best shot

157. According to LexMachina.com, the median time to final written decision is 545 days. Final Decision Timing for PTAB Trials, LEX MACHINA, INC., https://lexmachina.com/ (search conducted Aug. 28, 2018) [https://perma.cc/ZS4A-JP66].

158. 35 U.S.C. § 319 (2012).

159. According to DocketNavigator.com, appeals of PTAB decisions have been affirmed about 86 percent of the time. Document Search for "CAFC Opinion and Judgment on IPR/CBM Decision," DOCKET NAVIGATOR, INC., https://www.docketnavigator.com/ (search conducted Aug. 28, 2018) [https://perma.cc/YB3V-W23G].

160. 35 U.S.C. § 315(e)(2) (2012) ("The petitioner in an inter partes review . . . that results in a final written decision . . . may not assert either in a civil . . . or in a proceeding before the International Trade Commission . . . that the claim is invalid on any ground that the petitioner raised or reasonably could have raised during that inter partes review.").

161. *Id.* § 311(b) (2012) (limiting petitions to "grounds that could be raised under section 102 or 103 and only on the basis of prior art consisting of patents or printed publications").

162. *Id.*

at invalidating the patent on novelty and non-obviousness grounds before the PTAB.[163]

2. PTAB Proceedings vs. Court Proceedings

Challenging a patent's validity in an IPR has a number of advantages for the challenger relative to a validity challenge heard in court. For one, patent claims can be cancelled in an IPR upon a showing by a mere "preponderance of the evidence" that they lack novelty or are obvious,[164] while patents are presumed to be valid in court proceedings and, thus, must be proven invalid by "clear and convincing evidence."[165] In addition, while patent claims asserted in court are interpreted according to their "ordinary and customary meaning" to a person of ordinary skill in the art,[166] patent claims challenged in IPRs are given their "broadest reasonable construction" when compared to the prior art cited by petitioners.[167] Finally, as discussed above, IPRs in most instances promise faster and cheaper resolution. That said, IPRs are far from cheap in absolute terms. USPTO filing fees alone for an instituted IPR are

163. Estoppel applies not only to the named petitioner, but also to the "real party in interest" (RPI) behind the petitioner if another entity is actually in control. However, the PTAB has ruled that third parties can file IPRs without estopping their members as long as members do not control which IPRs are filed and how those IPRs are litigated. Unified Patents, Inc. v. Am. Vehicular Scies., LLC, No. IPR2016-00364 (P.T.A.B. June 27, 2016).

164. 35 U.S.C. § 316(e) (2012).

165. *See supra* note 50.

166. *See* Phillips v. AWH Corp., 415 F.3d 1303, 1312–13 (Fed. Cir. 2005) (en banc) ("[T]he words of a claim are generally given their ordinary and customary meaning. We have made clear, moreover, that the ordinary and customary meaning of a claim term is the meaning that the term would have to a person of ordinary skill in the art in question at the time of the invention, i.e., as of the effective filing date of the patent application." (internal quotation marks and citations omitted)).

167. 37 C.F.R. § 42.100(b) (2017) ("A claim in an unexpired patent that will not expire before a final written decision is issued shall be given its broadest reasonable construction in light of the specification of the patent in which it appears."). This advantage may soon go away. *See* Changes to the Claim Construction Standard for Interpreting Claims in Trial Proceedings Before the Patent Trial and Appeal Board, 83 Fed. Reg. 21221, 21221 (May 9, 2018) (to be codified at 37 C.F.R. pt. 42) [hereinafter Changes to the Claim Construction Standard] ("[T]he Office proposes to replace the broadest reasonable interpretation ('BRI') standard for construing unexpired patent claims and proposed claims in these trial proceedings with a standard that is the same as the standard applied in federal district courts . . . .").

$30,500,[168] and median legal fees required to pursue an IPR to a final written decision are estimated to be about $250,000.[169]

3. Controversy Surrounding PTAB Proceedings

To date, commentary on IPR has primarily focused on the procedure's high claim "kill rate." Numerous studies have documented the relatively high (though declining) rate of institution (79 percent of decisions on the merits),[170] as well as the fact that most IPRs that reach a final determination conclude with the cancellation of all instituted claims (70 percent of final written decisions).[171]

The high rate of claim cancellation in particular has attracted an enormous amount of attention, including fierce criticism from lobbies for patent owners, especially those representing the interests of biotech and pharmaceutical companies. Randall Rader, former Chief Judge of the U.S. Court of Appeals for the Federal Circuit, went as far as describing APJs as "acting as death squads, killing property rights,"[172] and some observers have voiced concerns that IPR may be detrimental to the proper functioning of the patent system and innovation more broadly.[173] Indeed, a bipartisan group of Senators has twice introduced legislation that, if enacted, would make dras-

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168. USPTO, FEE SCHEDULE, https://www.uspto.gov/learning-and-resources/fees-and-payment/uspto-fee-schedule#PTAB (last visited Jan. 14, 2018) [https://perma.cc/U7PS-4UKE] (showing a $15,500 "[i]nter partes review request fee" and a $15,000 "[i]nter partes review post-institution fee").

169. AIPLA, *supra* note 53, at I-162.

170. *Analytics: Cases by Status and Phase*, *supra* note 133.

171. *Id.* Overall, about 68 percent of claims that were the subject of an institution decision (on the merits of the petition) have been instituted, and about 82 percent of instituted claims that were the subject of a final written decision were cancelled. *Id.*

172. Tony Dutra, *Rader Regrets CLS Bank Impasse, Comments on Latest Patent Reform Bill*, BLOOMBERG BNA (Oct. 29, 2013), https://www.bna.com/rader-regrets-cls-b17179879919/ [https://perma.cc/458T-DREE].

173. *See, e.g.*, Peter J. Pitts, *'Patent Death Squads' vs. Innovation*, WALL ST. J. (June 10, 2015), https://www.wsj.com/articles/patent-death-squads-vs-innovation-1433978591 [https://perma.cc/S9KT-WGL8] ("The PTAB could devastate innovation-intensive industries."); Alden Abbott et al., *Crippling the Innovation Economy: Regulatory Overreach at the Patent Office*, REG. TRANSPARENCY PROJECT, https://regproject.org/paper/crippling-innovation-economy-regulatory-overreach-patent-office/ (last visited July 21, 2018) [https://perma.cc/QVG2-H3WV] ("The PTAB administrative tribunal is creating unnecessary costs for inventors and companies, and thus it is harming the innovation economy far beyond the harm of the bad patents it was created to remedy.").

tic changes to PTAB practice designed to benefit patent owners.[174] Yet another recently introduced bill would eliminate inter partes review and post-grant review entirely.[175] PTAB procedures have been attacked in the courts as well, where patent owners have argued that various aspects of PTAB practice either exceed congressional authority or are altogether unconstitutional.[176] While these arguments have thus far been largely unsuccessful, additional challenges are sure to follow.[177]

III. DATA COLLECTION AND METHODOLOGY

Rather than focus directly on this long-running debate, however, we take a step back and ask what more than four years' of PTAB decisions can teach us about the determinants of patent validity. As described in greater detail below, we take advantage of IPR's popularity and relatively low settlement rate to compare the characteristics of over 2,500 patents that were the subject of at least one "institution" decision issued by the PTAB between its founding in September 2012 and the end of January 2017. Here, we identify the sources of our data and explain our methodology.

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174. *See* Support Technology and Research for Our Nation's Growth (STRONG) Patents Act, S. 632, 114th Cong. (2015); Support Technology and Research for Our Nation's Growth and Economic Resilience (STRONGER) Patents Act of 2017, S. 1390, 115th Cong. (2017). For a summary of the bills' provisions, see Sen. Chris Coons, *The STRONGER Patents Act of 2017: Section by Section*, U.S. SENATE, https://www.coons.senate.gov/imo/media/doc/STRONGER%20Patents%20Act%20of%202017%20Section-By-Section.pdf [https://perma.cc/K62R-JDHA].

175. Restoring America's Leadership in Innovation Act of 2018, H.R. 6264, 115th Cong. (2018).

176. The Supreme Court of the United States recently decided two cases argued in October Term 2017. Oil States Energy Servs., LLC v. Greene's Energy Grp., LLC, 138 S.Ct. 1365, 1370 (2018) (holding that inter partes review violates neither Article III nor the Seventh Amendment of the U.S. Constitution); SAS Inst. Inc. v. Iancu, 138 S. Ct. 1348, 1352–53 (2018) (holding that when the PTAB "institutes" an IPR, its final written decision must address the patentability of *all* challenged claims).

177. Indeed, in *Oil States*, the Court expressly left open the possibility that IPR might violate the Constitution's Due Process or Takings Clauses. *See* 138 S. Ct. at 1379 ("[W]e address only the precise constitutional challenges that Oil States raised here. Oil States does not challenge the retroactive application of inter partes review, even though that procedure was not in place when its patent issued. Nor has Oil States raised a due process challenge. Finally, our decision should not be misconstrued as suggesting that patents are not property for purposes of the Due Process Clause or the Takings Clause.").

A. Inter Partes Review Petition-Level Data

To learn what PTAB outcomes can tell us about patent quality, we set out to gather as much data as we could on individual petitions. We began by obtaining data on PTAB proceedings from Unified Patents, Inc., which maintains a commercial database of PTAB statistics and filings.[178] Unified Patents provided us with petition-level data that allowed us to identify the patent challenged in each proceeding, as well as the proceeding's filing date, the date and outcome of all PTAB decisions, and the date and reason for each petition's termination. Our data includes all petitions filed through January 31, 2017.

As shown below in Table 1, our data includes 5,829 petitions, 4,903 of which were litigated to (at least) an institution decision. A small but noteworthy share of institution denials was based not on the merits of the validity arguments raised in the petition, but instead on a procedural defect.[179] Excluding these, we are left with 4,567 petitions challenging a total of 2,532 unique patents that were reviewed on their merits by the PTAB.

178. *Id.* A coauthor of this study, Shawn Ambwani, is the COO of Unified Patents.

179. A party seeking IPR of a patent asserted against it in court must, by statute, file a petition within one year of being sued. 35 U.S.C. § 315(b) (2012). If a party fails to seek IPR within that one-year window, its petition will be denied as untimely. The PTAB also may deny a petition without reaching its merits on the grounds that it is substantially duplicative of an earlier-filed petition. 35 U.S.C. § 325(d) (2012).

TABLE 1. PTAB data overview (Sept. 16, 2012 through Jan. 31, 2017)

	Number	Percent
Petitions	5,829	100
Pending, pre-institution	39	0.67
Settled, pre-institution	823	14.1
Adv. judgment, pre-institution	24	0.41
Other, pre-institution	43	0.74
Institution decisions	4,903	84.1
Granted	3,403	69
Denied – merits	1,164	24
Denied – procedural	336	7
Unique (Utility[a]) patents petitioned	3,920	100
Subject of inst. decision(s) on merits	2,532	65
Always granted	1,680	66
Always denied	671	27
Both granted and denied	181	7

[a] We excluded from our analysis a small number of petitions challenging design patents.

As of January 2017, only about 40 percent of these patents were the subject of a final written decision. The large drop in the number of decisions is a result of two factors. The first is a pipeline effect caused by the fact that final written decisions are typically not issued until very close to one year after their corresponding institution decision. The second reason is settlement. Overall, about one-third of PTAB petitions settle, and about half of settlements take place after an institution decision has been issued.[180]

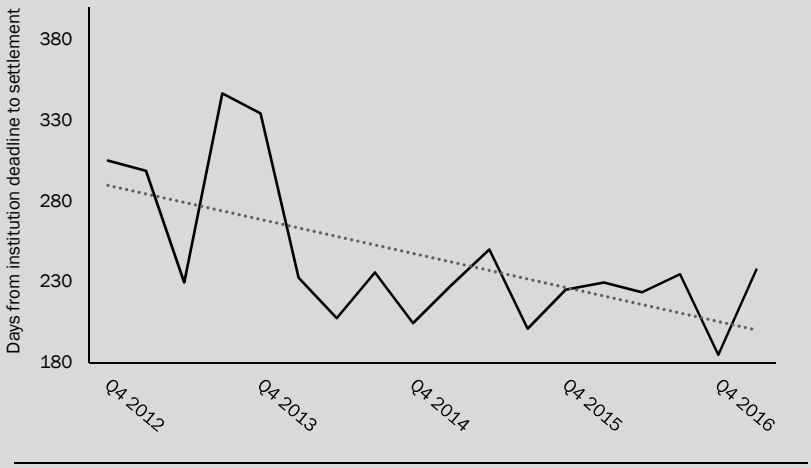
In those petitions litigated to a final written decision, the PTAB overwhelmingly decided to cancel at least one instituted claim. Overall, final written decisions have cancelled about 82 percent of the instituted claims they reviewed, and about 73 percent of final written decisions issued to date cancelled *all* instituted claims.[181] Indeed, it is our experience that parties to

180. *Analytics: Cases by Status and Phase*, *supra* note 133.

181. *Id.* While this rate is high, it is hardly surprising. Final written decisions are decided by the same panel of APJs that voted less than a year prior to institute the petition on the grounds that the very same claims were shown to be unpatentable to a "reasonable likelihood."

PTAB proceedings generally view the institution decision as the most consequential decision in a PTAB proceeding. Instituted claims, it is generally assumed, will be cancelled if competently litigated to a conclusion. Thus, an institution decision alone is often sufficient to destroy the majority of a claim's licensing value. Indeed, as depicted in Figure 1, it is increasingly likely for PTAB proceedings to settle shortly before or shortly after the institution decision, which must be made within six months of the date of petition.[182]

FIGURE 1: Monthly average days from IPR petition to settlement.



Note: Monthly averages calculated from population of IPR proceedings that ended in settlement. Linear trend included with a slope of 5.7 fewer days from petition to settlement each month. Chi-square test rejected the null that the time from petition to settlement is not declining (p = 0.000).

B. PTAB Institution as a Quality Filter

Because of the pivotal role that institution plays in PTAB practice, we use merits-based institution decisions in this study as our primary indicator of patent quality. That is, we assume that challenged patents that were flagged by a panel as having at least one likely invalid claim are of relatively "low quality" while patents that were challenged but never instituted on any

182. 35 U.S.C. § 314(b) (2012); 37 C.F.R. § 42.107(b) (2017).

claims are of relatively "high quality." While we explain our precise classification methodology in greater detail immediately below, we pause here to explain why we believe that institution decisions are a valid quality filter.

For one, as explained above, we believe that a focus on institution decisions accurately reflects the current state of patent practice. Overwhelmingly, instituted claims are cancelled in final written decisions, and IPRs frequently settle just before or after an institution decision is issued. We believe that employing institution decisions as a quality filter is advantageous for a number of additional reasons. First, we believe that institution decisions reflect with a high degree of accuracy whether the challenged patent claims should have originally been granted. An instituted petition has demonstrated to the satisfaction of a panel of Administrative Patent Judges that the challenged patent includes at least one claim that likely should not have been issued.[183] Unlike decisions made in court, PTAB decisions employ the same interpretive rules, legal standard, and burden of proof applicable in ex ante examination.[184] Moreover, all APJs have a technical degree in science or engineering as well as experience working as a patent examiner or patent lawyer (if not both),[185] and thus may be better positioned than judges or juries to understand both patentees' inventions and the prior art raised by petitioners.[186]

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183. Moreover, almost all decisions issued by panels are unanimous. *See* Scott McKeown, *Judicial Independence & The PTAB: The Tension Between Judicial Independence & Agency Consistency*, ROPES & GRAY: PATENTS POST-GRANT (Dec. 12, 2017), https://www.patentspostgrant.com/judicial-independence-ptab/#more-12559 [https://perma.cc/F9Z7-KPSA] (reporting that 98 percent of all PTAB institution decisions and final written decisions are unanimous).

184. *See* MPEP § 2111 (9th ed. Rev. Aug. 2017) ("Patented claims are not given the broadest reasonable interpretation during court proceedings involving infringement and validity, and can be interpreted based on a fully developed prosecution record."). However, as mentioned above, this may soon change. *See* Changes to the Claim Construction Standard, *supra* note 167.

185. *See* David Ruschke, Chief Judge, U.S.P.T.O., Powerpoint Presentation at Santa Clara Fireside Chat: State of the Board After 5 Years (Nov. 16, 2017) (copy on file with the authors) (noting that APJs have technical degrees in addition to law degrees, with more than 10 percent of APJs holding a PhD, about 27 percent holding a master's degree in a technical field, and about 32 percent having prior experience working as a USPTO patent examiner).

186. *See, e.g.*, Michael Goodman, *What's So Special About Patent Law?*, 26 FORDHAM INTELL. PROP. MEDIA & ENT. L.J. 797 (2016) (arguing that the PTAB should become the exclusive forum for validity challenges because "the difficult portion of a patent case is the technology" and APJs have "the necessary expertise to deal with that technology"); *see also* Gen. Tire & Rubber Co. v. Jefferson Chem.

Second, we believe that institution decisions likely suffer from fewer selection effects than validity decisions rendered by courts. While we acknowledge that patents challenged in PTAB proceedings are highly selected, there is good reason to believe that challenged patents are *less* selected than patents litigated to a decision by a judge or jury.[187] For one, a PTAB challenge is much more likely than a lawsuit to lead to a decision on the merits. In an analysis of the more than 5,100 patent suits filed in U.S. courts in 2008 and 2009, Allison et al. found just 430 validity decisions.[188] By contrast, the more than 5,800 PTAB IPR petitions in our data set generated institution decisions for 2,532 unique patents, and many of these petitions are still pending.

In addition, there is good reason to believe that the set of patent disputes worth litigating to a decision on the merits is a subset of the patent disputes worth challenging before the PTAB. Though it is true that just 15 percent of patents asserted in court are challenged at the PTAB,[189] an even smaller percentage of patent suits are litigated to a motion for summary judgment.[190] We believe that cases traditionally falling in the latter category are likely today to fall in the first as well. Simply put, disputes worth litigating for two to three years at a cost well north of $1 million[191] are, with high probability, also worth challenging at the PTAB for eighteen

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Co., 497 F.2d 1283, 1284 (2d Cir. 1974) ("This patent appeal is another illustration of the absurdity of requiring the decision of such cases to be made by judges whose knowledge of the relevant technology derives primarily, or even solely, from explanations of counsel and who, unlike the judges of the Court of Customs and Patent Appeals, do not have access to a scientifically knowledgeable staff.").

187. To be clear, though we believe that the population of petitioned patents suffers from less selection bias than the population of litigated patents, we also acknowledge that petitioned patents are nonetheless still a highly selected group and, thus, different from the population of granted patents. Consistent with the literature showing a connection between litigation and private value, we suspect that the principal difference between petitioned patents as a group and the population of all U.S. patents is that the former have greater private value.

188. Allison et al., *supra* note 8, at 1778.

189. *Analytics: Cases by Status and Phase*, *supra* note 133.

190. Case Resolutions for District Court Patent Cases, LEX MACHINA, INC., https://lexmachina.com/ (search conducted July 27, 2017) [https://perma.cc/ZS4A-JP66].

191. See AIPLA, *supra* note 53, at I-121 (reporting a median cost of $1 million to litigate a patent case with between $10 million and $25 million at stake through claim construction).

months and closer to $250,000.

Finally, at least some patent disputes that are *not* worth litigating to a decision nonetheless still *are* worth challenging at PTAB. In addition to the fact that PTAB proceedings are simply less expensive than litigation, because IPR has no standing requirement, potential infringers can pool resources in third-party organizations—like defensive aggregators and industry associations—that can challenge especially weak patents previously asserted en masse for nuisance value.[192] For example, in 2016 Unified Patents instituted a challenge against a patent owned by Shipping & Transit, LLC (formerly known as ArrivalStar, LLC), which had previously filed hundreds of patent suits with an average time to termination of just 114 days.[193] Though few parties would elect to defend a lawsuit that could be settled for a five-figure sum, third party organizations that serve the interests of dozens or hundreds of potential lawsuit targets often will have the incentive to launch a PTAB challenge. In addition, roughly fifteen percent of PTAB proceedings challenge a patent that has never been asserted in court.[194] Such challenges may happen for a variety of reasons and, thus, allow us to observe the validity of patents that otherwise may never have been selected for litigation.

C. Classifying High- and Low-Quality Patents

Accordingly, we chose merits-based institution decisions to classify patents as either "high" or "low" quality. While we could have instead categorized patents using only the outcomes of PTAB final written decisions, we chose not to because doing so would have substantially reduced the size of our sample,

192. *See* Love, *supra* note 147, at 1094 n.59 ("A small but growing number of IPRs have been filed by industry groups (like the Printing Industries of America), public interest organizations (like the Electronic Frontier Foundation), and membership-based patent risk management firms (like RPX and Unified Patents). By pooling resources ex ante, these groups also help mitigate the collective action problem that arises when multiple purchasers, rather than one manufacturer, is faced with infringement allegations."). To date, Unified Patents and RPX have collectively filed 175 petitions for inter partes review. PTAB Trials for Party Group RPX Corp. and Unified Patents, Inc., LEX MACHINA, INC., https://lexmachina.com/ (search conducted Jan. 23, 2018) [https://perma.cc/ZS4A-JP66].

193. Termination Timing for Party Group Shipping & Transit, LLC and ArrivalStar S.A., LEX MACHINA, INC., https://lexmachina.com/ (search conducted July 27, 2017) [https://perma.cc/ZS4A-JP66].

194. *Analytics: Cases by Status and Phase*, *supra* note 133.

while at the same time increasing selection effects. Though we feel confident in this choice given the high rate of claim cancellation observed in final written decisions, it is nonetheless possible for a final written decision to confirm the patentability of all instituted claims and, in effect, "reverse" the institution decision. While this is rare, it does happen from time to time. To correct for these "reversals," we re-classified petitions as "not instituted" if all instituted claims were upheld in a final written decision.

With that correction made, as shown above in Table 1, the population of patents that were the subject of at least one merits-based institution decision can be divided into three sets: (1) 1,680 patents that were instituted every time they were the subject of an institution decision, i.e., patents that were "always instituted"; (2) 671 patents that were *not* instituted every time they were the subject of an institution decision, i.e., patents that were "never instituted"; and (3) 181 patents that were both instituted at least once on the merits *and* were not instituted at least once on the merits.

In the analyses described below, we consolidate these three sets in two ways to compare patents that are of relatively "high" and relatively "low" quality. First, we create a dichotomous variable that compares the set of 671 patents that were "never instituted" (and thus of relatively high quality) to the set of 1,861 patents that were instituted at least once (and thus of relatively low quality). This compares patents that passed PTAB scrutiny with flying colors against patents with at least one challenged claim that appears to have been issued erroneously.

While such a comparison is useful from a policy perspective—after all, in an ideal world, the USPTO would only issue valid claims—it is arguably the wrong comparison to make from a practical perspective. Victory in a patent enforcement action requires a finding of infringement of just a single valid claim. Thus, a patent with one rock-solid claim can remain a significant hurdle to competitors despite containing numerous additional claims that are likely invalid. With this consideration in mind, we created a second dichotomous variable that compares the set of patents that were not instituted on the merits at least once (and thus of relatively high quality) with the set of patents that were "always instituted" (and thus of relatively low quality). This comparison is marginally more

practical in that it compares patents that withstood at least one well-funded validity challenge against those that fell at least in part each time they were scrutinized.

That said, one limitation to our study is that we lack data on patent claim-level outcomes. For practical reasons related to the difficulty inherent in collecting such data from court filings, we did not track the fate of each individual patent claim that was challenged. Thus, we lack the ability to identify patents that were instituted at least once on each and every challenged claim despite surviving at least one petition among many. Similarly, we are unable to identify patents that survived IPR with at least one challenged claim intact despite being instituted each time a petition was filed. We hope in future iterations of this study to expand our analysis to include claim-level comparisons.

D. Patent-Level Data Collection Methodology

With our patents classified by quality, we next collected as much patent-level data as possible that might predict in some way a patent's quality. The data that we collected falls into five broad categories: (1) characteristics of the patent's applicant, prosecution counsel, and examiner; (2) the type of technology that the patent relates to; (3) the complexity of the patent document itself; (4) the intensity of the patent's prosecution and examination; and (5) attributes that the patent acquired over time post-grant. Unless otherwise indicated, we queried the data described below from the USPTO's recently released "PatentsView"[195] and "PatEx"[196] databases.

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195. PatentsView is a relational database that links individual U.S. patent numbers ("patent_id") to, among other things, data on patent assignees, claims, inventors, lawyers, reverse citations, and technology classifications. *See* USPTO, FAQs, http://www.patentsview.org/api/faqs.html [https://perma.cc/H5LK-Q3WB] (last visited Aug. 9, 2018). We downloaded a copy of the database, USPTO, DATA DOWNLOAD TABLES, http://www.patentsview.org/download/ [https://perma.cc/HTL7-E9F2] (last visited Aug. 9, 2018), and queried it using SQL scripts. PatentsView can now be queried directly via Google's BigQuery platform. *See* Ian Wetherbee, *Google Patents Public Datasets: Connecting Public, Paid, and Private Patent Data*, GOOGLE CLOUD BLOG (Oct. 31, 2017), https://cloud.google.com/blog/big-data/2017/10/google-patents-public-datasets-connecting-public-paid-and-private-patent-data [https://perma.cc/3HNC-9HUP].

196. PatEx is a relational database that links individual U.S. patent application numbers ("application_number") to, among other things, data on patent examiners, parent applications, child applications, and "events" that

1. Applicant, Prosecutor, and Examiner

The first category of data that we collected pertains to the people and entities that controlled each patent's filing and examination. In addition to identifying each patent's applicant, we noted whether the applicant claimed "small entity" status at the time of filing in order to receive fee discounts available to businesses with fewer than five hundred employees.[197] We also hand-classified each applicant as: one or more individuals (typically the patent's inventor(s)), a for-profit business entity (typically the employer of inventors working in a corporate research setting), a university or university-affiliated entity (typically the employer of inventors working in an academic research setting),[198] or, finally, a government department or government-run research lab (typically the employer of inventors working in a non-academic research setting).[199]

We next identified the people or entities selected by each applicant to prosecute the application from which each patent issued. Then we categorized each application as prosecuted by one or more of the patent's inventors (i.e., prosecuted "pro se"), by lawyers employed by the applicant (i.e., by the applicant's "in-house" legal team), or by lawyers employed by an outside law firm. For each application prosecuted by a law firm, we additionally categorized the firm by size, measured by the number of attorneys employed by the firm.[200] For this purpose, we

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occurred during prosecution. Stuart J.H. Graham et al., *The USPTO Patent Examination Research Dataset: A Window on the Process of Patent Examination* (USPTO, Econ. Working Paper No. 2015-4, Nov. 2015), https://www.uspto.gov/sites/default/files/documents/PatEx%20Working%20Paper.pdf [https://perma.cc/7MF9-45NH]. We downloaded a copy of the database, *See* USPTO, PATENT EXAMINATION RESEARCH DATASET (Public PAIR), https://www.uspto.gov/learning-and-resources/electronic-data-products/patent-examination-research-dataset-public-pair [https://perma.cc/EG4U-E8JK], and queried it using SQL scripts. This data can now be queried directly via Google's BigQuery platform. *See* Wetherbee, *supra* note 195.

197. 13 C.F.R. § 121.802(a) (2018) ("A concern eligible for reduced patent fees is one . . . [w]hose number of employees, including affiliates, does not exceed 500 persons . . . .").

198. In addition to universities, we included in this category about two-dozen affiliated nonprofit entities. These were primarily university-affiliated hospitals.

199. Because we found just five government patents, we do not discuss them separately.

200. We primarily collected this information by visiting each firm's website. In some instances, firms had merged with others since the time of prosecution. In those circumstances, we attempted to the best of our ability to determine the size

adopted the size classifications used by the AIPLA in its biannual *Report of the Economic Survey*, which groups firms into the following categories: "large" firms, which employ 60 or more attorneys; "medium" firms, which employ 16 to 59 attorneys; "small" firms, which employ 4 to 15 attorneys; and "solo" practices, which employ 3 or fewer attorneys.[201]

Finally, we identified the USPTO examiner who was assigned to examine the application from which each patent issued.[202] For each examiner, we identified his or her level of "experience," measured by the total number of applications that he or she had examined in his or her career. Building on this data point, we next calculated the examiner's overall "allowance rate," measured by the percentage of each examiner's applications that were granted. We then identified the "art unit" in which each examiner worked,[203] and calculated each art unit's overall allowance rate. Finally, using both examiner and art unit allowance rates, we calculated each examiner's relative allowance rate—that is, the differential between each examiner's individual allowance rate and the average allowance rate across all other examiners working in his or her respective art unit.

2. Technology Area

Next, we collected data about the technological focus and scope of each challenged patent. First, we collected data on the number and type(s) of technology "classifications" assigned to the patent, including those classes and subclasses assigned under the USPTO's "U.S. Patent Classification System" (USPC), the USPTO and EPO's joint "Cooperative Classification System" (CPC), and the WIPO's "International Patent Classifi-

of the firm before the merger. Often this was possible by locating press releases announcing the merger.

201. *See, e.g.*, AIPLA, *supra* note 53, at I-93.

202. The examiners assigned to five patents were missing from the PatEx database. We exclude those patents from the examiner-related analyses reported infra in Tables 4, 18, and 19.

203. U.S. patent examiners are divided into nine "technology centers," each of which is subdivided into a number of "work units" that, in turn, are further subdivided into "art units." *See* USPTO, PATENT TECHNOLOGY CENTERS MANAGEMENT, https://www.uspto.gov/patent/contact-patents/patent-technology-centers-management (last visited Aug. 30, 2018) [https://perma.cc/SH3Y-PCEM].

cation System" (IPC).[204] Using these classifications, we further defined a set of "pharmaceutical" patents,[205] a set of "business method" patents,[206] and a set of "software" patents.[207] Finally, to supplement these class-based categories, we hand-classified each patent as broadly related to "high tech" (i.e., computing and telecommunications), "medical" technology (i.e., pharmaceuticals, biotechnology, and medical devices), or some "other" technology.[208]

3. Specification and Claims

We next collected data related to the length and complexity of various parts of the patent document itself. For each patent, we identified its total number of claims as well as the number of independent and dependent claims. We also determined the length (measured by word count) of various parts of each patent document, including each patent's abstract, specification, and claims. Finally, to correct for the common repetition of words or phrases in claim language, we took the additional step of noting the number of unique words that appear in each patent's first (and typically principal) claim.

4. Prosecution History and Family

Turning from patent documents to prosecution histories, we next collected data about each patent's examination. First, we took the simple step of noting the date on which each patent's application was filed, the filing date of the earliest prior application to which it claimed priority, and the date on which the application was granted. From this data, we calculated each patent's "pendency," that is, the duration of the patent's

204. *See* USPTO, CLASSIFICATION STANDARDS AND DEVELOPMENT, https://www.uspto.gov/patents-application-process/patent-search/classification-standards-and-development (last visited Aug. 9, 2018) [http://perma.cc/PG42-B5U4].

205. We define "pharmaceutical" patents as those assigned to USPC 514 or 424.

206. We define "business method" patents as those assigned to USPC 705 or any USPC in the range 718 to 726.

207. Following Bessen, we define "software" patents as those assigned to any of the following USPCs: 341, 345, 370, 375, 380, 381, 382, 700–07, 715–17, 726, and 902. James Bessen, *A Generation of Software Patents*, 18 B.U. J. SCI. & TECH. 241, 253 (2012).

208. Such as manufacturing, industrial, and oil and gas related technologies.

prosecution history.

We next identified all prior art references that were cited during the patent's prosecution (often referred to as "backward" or "reverse" citations). In addition to determining the overall count of such citations, we determined the number of backward citations to foreign patents, as well as the number and type of backward citations to "non-patent literature" (NPL) such as academic articles, books, and websites. Finally, for all patents issued in 2001 or thereafter, we determined whether backward citations to patents and applications were disclosed by the applicant or, instead, were identified and cited by the examiner in an office action.[209]

In addition to the documents cited during prosecution, we searched USPTO records to identify whether (and if so how often) certain actions were taken by the applicant or examiner during prosecution. For example, we identified whether the applicant disclosed prior art references to the examiner in an "information disclosure statement" (IDS), and if so how many times. Similarly, we identified whether, and if so how many times, the examiner "rejected" the application in an office action. In addition, in response to a "final" rejection (if any) we noted whether the applicant filed a "request for continued examination" or, alternatively, filed a notice of appeal to the Board of Patent Appeals and Interferences.

We also noted whether each patent's application was published prior to issuance.[210] If so, we noted the number of claims and total word count of those claims at the time of publication, and compared those figures to the total number of claims and

209. Our ability to distinguish between applicant- and examiner-cited prior art is limited in two important respects. First, PatentsView only distinguishes between applicant- and examiner-cited prior art *patents or applications*; it does not distinguish between applicant- and examiner-cited NPL. Second, PatentsView only includes this (partial) data for patents issued after 2000.

210. U.S. patent applications filed on or after November 29, 2000, are generally published eighteen months after their filing date. *See, e.g.*, USPTO, USPTO WILL BEGIN PUBLISHING PATENT APPLICATIONS (Nov. 27, 2000), https://www.uspto.gov/about-us/news-updates/uspto-will-begin-publishing-patent-applications [https://perma.cc/5GY9-RB8M] (noting that the publication mandate "stems from a statutory mandate contained in the American Inventors Protection Act of 1999 (AIPA)" and that "[t]here are exclusions from the publication requirement, the most significant of which is for applicants who attest upon filing that they have not and will not file an application for the same invention in a foreign country or under a multilateral international agreement, that requires publication of applications 18 months after filing").

word count at the time of the application's issuance as a granted patent.[211] Lastly, we identified whether each applicant sought patent protection solely in the United States or, instead, prosecuted a "family" of similar applications in various patent offices across the globe. For each patent with foreign family members, we additionally noted the total number of its foreign counterparts, as well as the specific patent office in which each was filed.

5. Characteristics Acquired Post-Grant

Our final data collection efforts focused on characteristics acquired by each patent since the time it was granted. First, we identified how many times each patent had been cited during the prosecution of other, newer patents (i.e., "forward citations").[212] We also determined whether each patent had changed hands post-issuance and, if so, how many times.[213] Finally, we identified the current owner of the patent—that is, the respondent to each IPR—and classified each owner as either an operating company, a "patent assertion entity" specializing in patent monetization, or some other form of "non-practicing entity" that does not presently commercialize the patented technology.[214]

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211. Here we follow the lead of Alan C. Marco et al., *Patent Claims and Patent Scope* (Hoover Inst. Working Grp. on Intell. Prop., Working Paper No. 16001, Aug. 18, 2016), https://issuu.com/hooverip2/docs/ip2-wp16001-paper [https://perma.cc/432C-3BBB].

212. *See supra* notes 27–33 and accompanying text.

213. We obtained this information from AcclaimIP, which maintains a cleaned version of the USPTO assignment database. *See Number of Post-Grant Assignment Events*, ACCLAIMIP, http://help.acclaimip.com/m/acclaimip_help/l/181377-number-of-post-grant-assignment-events -ana_anre_pexe_ct (last visited Jan. 31, 2018) [https://perma.cc/6VKE-GUWG]. USPTO assignment records include many entries that do not represent true transfers, including the recording of security interests and corporate mergers or name changes. *See, e.g.*, Carlos J. Serrano, *The Dynamics of the Transfer and Renewal of Patents*, 41 RAND J. ECON. 686, 691 (2010) (explaining that many recorded assignments do not represent "transaction[s] of patents across firm boundaries," and instead result from "administrative events, such as a name change, a security interest, a correction, and so on," or "transactions between inventors-employers and their employees-assignees").

214. We hand coded these classifications relying on publicly available data, including information provided in documents filed in patent suits, entities' websites, and other public information regarding entities' owners, parents, employees, and current and former products.

IV. BIVARIATE RESULTS

With this patent-level data collected, we next performed a bivariate comparison of each metric across high- and low-quality patents to identify promising candidates for further multi-variate analysis (reported in Part V *infra*). As discussed above, we report two comparisons for each data point. The first compares patents that were never instituted against those that were instituted at least once. The second compares patents that were not instituted at least once and patents that were instituted every time they were challenged.[215]

A. Applicant, Prosecutor, and Examiner

Looking first at the characteristics of patents' applicants, prosecutors, and examiners, we find a number of statistically significant differences between patents that were and were not successfully challenged in inter partes review. As shown below in Table 2, we first note that patents originally obtained by small entities are significantly less likely to pass muster in a PTAB institution decision.[216] To a lower 90 percent confidence level, the same is true of patents originally obtained by individuals. Notably, both findings are consistent with prior research suggesting that patentee sophistication and resources influence patent validity.[217]

215. For dichotomous variables, we report the results of Chi-square tests of the null that there is no difference in the institution rate of patents with or without the characteristic. For continuous variables, we report the results of t-tests comparing the mean number of the variable for patents never instituted versus instituted and separately denied institution versus always instituted.

216. We do not analyze government-assigned patents because there were only five in our dataset.

217. For example, relative to larger entities, small entities may tend to select lower-quality patent prosecution counsel, or may not be able to spend as much on prosecution-related services generally.

TABLE 2. Applicant characteristics

	N		Yes	No	*p*
Small entity?	754 / 2532	Never inst.	24% (182)	28% (489)	0.085*
		Instituted	76% (572)	72% (1289)	
		Denied inst.	30% (226)	35% (626)	0.011**
		Always inst.	70% (528)	65% (1152)	
Individual?	290 / 2532	Never inst.	23% (68)	27% (603)	0.230
		Instituted	77% (222)	73% (1639)	
		Denied inst.	29% (85)	34% (767)	0.099*
		Always inst.	71% (205)	66% (1475)	
Corporation?	2148 / 2532	Never inst.	27% (573)	26% (98)	0.661
		Instituted	73%(1575)	74% (286)	
		Denied inst.	34% (736)	30% (116)	0.128
		Always inst.	66%(1412)	70%(268)	
University?	89 / 2532	Never inst.	31% (28)	26% (643)	0.274
		Instituted	69% (61)	74% (1800)	
		Denied inst.	33% (29)	34% (823)	0.909
		Always inst.	67% (60)	66% (1620)	

Note: Population of 2,532 patents subject to an inter partes review institution decision on the merits between September 16, 2012, and January 31, 2017. Some patents were the subject of multiple merit institution decisions and accordingly, "Never inst." versus "Instituted" compares the 671 petitioned patents never instituted on the merits to the 1,861 patents instituted at least once. "Denied inst." versus "Always inst." compares the 852 patents denied institution on the merits in at least one petition to the 1,680 patents always instituted. Institution rates with number of patents in parenthesis. Significant differences in institution rates designated: * for $p < .10$; **for $p < .05$; and *** for $p < .01$.

Turning to choice of prosecution counsel, we also find significant results. As shown below in Table 3, we find that patents prosecuted by large firms were less likely to be instituted, while patents prosecuted by solo practitioners were more likely to be instituted. While these correlations may have many drivers,[218] we note that law firm size itself is positively correlated with hourly rates charged for legal work and attorney salaries, both of which may suggest that large law firms (on average) produce better legal work product and attract more highly skilled attorneys than their smaller counterparts.

218. For example, while these correlations may suggest that large firms produce better legal work product than smaller firms, they are also consistent with the hypothesis that inventors with especially novel inventions are disproportionately likely to hire large firms as prosecution counsel.

TABLE 3. Prosecuting counsel characteristics

	N		Yes	No	*p*
Large firm	1017 / 2532	Never inst.	31% (316)	23% (355)	0.000***
		Instituted	69% (701)	77% (1160)	
		Denied inst.	38% (390)	30% (426)	0.000***
		Always inst.	62% (627)	70% (1053)	
Medium firm	495 / 2532	Never inst.	24% (117)	27% (554)	0.112
		Instituted	76% (378)	73% (1483)	
		Denied inst.	31% (152)	34% (700)	0.124
		Always inst.	69% (343)	66% (1337)	
Small firm	439 / 2532	Never inst.	24% (107)	27% (564)	0.285
		Instituted	76% (332)	73% (1529)	
		Denied inst.	31% (138)	34% (714)	0.292
		Always inst.	69%(301)	66% (1379)	
Solo	348 / 2532	Never inst.	20% (71)	27% (600)	0.005***
		Instituted	80% (277)	73% (1584)	
		Denied inst.	28% (96)	35% (756)	0.010**
		Always inst.	72% (252)	65% (1428)	
In house	218 / 2532	Never inst.	26% (57)	27% (614)	0.936
		Instituted	74% (161)	73% (1700)	
		Denied inst.	33% (71)	34% (781)	0.765
		Always inst.	67% (147)	66% (1533)	
Pro se	15 / 2532	Never inst.	20% (3)	27% (668)	0.772
		Instituted	80% (12)	73% (1849)	
		Denied inst.	33% (5)	34% (847)	1.000
		Always inst.	67% (10)	66% (1670)	

Note: Population of 2,532 patents subject to an inter partes review institution decision on the merits between September 16, 2012, and January 31, 2017. Some patents were the subject of multiple merit institution decisions and accordingly, "Never inst." versus "Instituted" compares the 671 petitioned patents never instituted on the merits to the 1,861 patents instituted at least once. "Denied inst." versus "Always inst." compares the 852 patents denied institution on the merits in at least one petition to the 1,680 patents always instituted. Institution rates with number of patents in parenthesis. Significant differences in institution rates designated: * for $p < .10$; **for $p < .05$; and *** for $p < .01$.

We again see significant correlations between institution and patent examiner characteristics. In fact, as shown below in Table 4, we find a significant correlation between institution and every metric that we measured. First, and most intuitively, we find a number of significant positive correlations between

likelihood of institution and the grant rates of individual examiners and art units. On average, instituted patents were more likely to have been assigned to examiners with higher overall allowance rates, to art units with higher overall allowance rates, and to examiners who granted applications more often than their counterparts in the same art unit.[219]

Second, and less intuitively, we also find a significant positive correlation between likelihood of institution and examiner experience. While at first blush one might expect examiners to improve with experience, our finding is consistent with a growing body of research indicating the opposite.[220] Prior studies have identified what we call a "promotion effect" and a "time allocation effect" that may degrade average examiner performance over time. The promotion effect captures two potential influences on examiner performance: first, a tendency for relatively lenient examiners to work for the USPTO for longer periods of time than their stricter counterparts,[221] and second, a tendency for more senior examiners with greater job security to be less diligent.[222] The time-allocation effect may reflect the

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219. The first two of these three findings may reflect to some extent that examiners assigned to an art unit covering more complex technology are given more time to examine patent applications. *See* Frakes & Wasserman, *supra* note 95, at 552. However, this fact cannot explain our finding that institution is also correlated with the differential between an examiner's grant rate and that of his or her colleagues in the same art unit. It is also noteworthy that this grant rate differential is positive even for patents that were denied institution.

220. *See* Mark A. Lemley & Bhaven Sampat, *Examiner Characteristics and Patent Office Outcomes*, 94 REV. ECON. & STATS. 817, 821 (2012) (finding that examiner "grant rate[s] increase[] monotonically with experience"); Mann, *supra* note 58, at 2176 (finding "that increasing experience relates to a decline in the quality of output" of USPTO examiners); Cockburn et al., *supra* note 20, at 46–47 (finding, despite hypothesizing the opposite, that "if anything, invalid patents are associated with examiners with higher mean levels of experience, both in terms of volume and tenure").

221. *See* Lemley & Sampat, *supra* note 220, at 824 ("[T]he PTO faces significant employee attrition, particularly among examiners who have been with the agency less than five years. If examiners who were more diligent, more thorough, more technically sophisticated, or more highly educated were more likely to leave the PTO earlier in their careers, perhaps because they have better job opportunities, this could provide one explanation for our results."). Other possible causes include that delivering good news is generally viewed as more enjoyable than delivering bad news and that granting applications requires less effort than rejecting them, both of which may make the job less stressful and more manageable for those who grant more often.

222. Most notably, "[e]xaminers at pay grades GS-13 and below must have their decisions reviewed by an examiner who has 'full signatory authority.'" Frakes & Wasserman, *supra* note 95, at 552. Frakes and Wasserman find that

simple fact that more senior examiners are expected to review more applications than their more junior counterparts, and thus have less time per application to devote to the examination.[223] While we lack the data to pass judgment on the existence of either effect, our findings nonetheless suggest quite consistently that experienced examiners are sub-optimally incentivized to produce high-quality patents.[224]

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examiner "grant rate jumps distinctly once one enters [GS-Level 14] (to a degree that is 8 percentage points higher than the reference period)." *Id.* at 556; *see also* Lemley & Sampat, *supra* note 220, at 825 ("Another possibility is examiner tenure. After promotion, examiners are not subject to the same level of scrutiny. Among other things, with full signatory authority, they can sign off on their own applications without review. This could plausibly cause them to be more lax."); *id.* at 826 (finding that "more senior examiners systematically cite less prior art[, which] reinforces the inference that senior examiners are doing less work, rather than that they are merely getting it right more often than junior examiners"); Sean Tu & Chris Holt, *Office Actions per Grant Ratio (OGR): A New Metric for Patent Examiner Activity*, PATENTLY-O (Apr. 5, 2018), https://patentlyo.com/patent/2018/04/actions-examiner-activity.html [https://perma.cc/H6QA-8F5S] (reporting that "junior examiners have a much lower allowance rate and a much higher OGR score than their more experienced counterparts").

223. Frakes & Wasserman, *supra* note 95, at 552.

224. To further investigate the relationship between examiner experience and allowance rates, we ran a few additional multivariate regressions. While we found no significant correlation between examiner experience and art unit allowance rates, we did find a significant correlation between examiner experience and an examiner's overall allowance rate. When we regressed the probability of a patent's institution on both examiner experience and examiner allowance rate, we found a significant positive correlation with examiner allowance rate but not with examiner experience. We discuss this finding further in Part V *infra*, but note for now that experienced examiners tend to be more lenient while only some lenient examiners are more experienced. Finally, and interestingly, when we regressed the probability of institution on both the art unit allowance rate and the examiner's allowance rate relative to the art unit, we found a significant correlation to both. This finding suggests that petitioned patents from more lenient art units are of lower quality regardless of the leniency of the particular examiner they were assigned to, and that patents assigned to more lenient examiners are of lower quality regardless of the leniency of that examiner's art unit.

TABLE 4. Examiner characteristics

	N		Mean	*p*
No. of applications per examiner	2527	Never inst.	1121 (670)	0.001***
		Instituted	1248 (1857)	
		Denied inst.	1150 (851)	0.005***
		Always inst.	1247 (1676)	
Examiner's overall allowance rate	2527	Never inst.	73% (670)	0.000***
		Instituted	78% (1857)	
		Denied inst.	74% (851)	0.000***
		Always inst.	78% (1676)	
Art unit allowance rate	2532	Never inst.	71% (671)	0.000***
		Instituted	75% (1860)	
		Denied inst.	72% (852)	0.000***
		Always inst.	75% (1679)	
Allowance rate differential (relative to art unit)	2527	Never inst.	1.8% (670)	0.002***
		Instituted	3.6% (1857)	
		Denied inst.	2.3% (851)	0.027**
		Always inst.	3.5% (1676)	

Note: Population of 2,532 patents subject to an inter partes review institution decision on the merits between September 16, 2012, and January 31, 2017.We exclude five patents assigned to examiners that do not appear in the PatEx database. Some patents were the subject of multiple merit institution decisions and accordingly, "Never inst." versus "Instituted" compares the mean value of a trait for the 671 petitioned patents never instituted on the merits to the mean value for the 1,861 patents instituted at least once. "Denied inst." versus "Always inst." compares the mean value of a trait for the 852 patents denied institution on the merits in at least one petition to the mean for the 1,680 patents always instituted. Significant differences in means across institution categories designated: * for $p < .10$; **for $p < .05$; and *** for $p < .01$.

B. Patent Characteristics

Turning next to the characteristics of challenged patents themselves, we find significant correlations. First, as shown below in Table 5, our findings suggest that "older" patents tend to be of lower quality than those filed and issued more recently. We find a significant positive correlation between likelihood of institution and the amount of time that has passed since the filing date of the earliest application to which the petitioned patent claims priority, the filing date of the application from which the petitioned patent issued, and the date on which the petitioned patent was issued.

While these correlations may have a number of explanations, it is hard to overlook the fact that courts have made a

number of substantive changes to U.S. patent law in the last two decades. Due to their retroactive application, these changes will naturally tend to reduce the quality of older patents that were examined in light of older case law. In addition to case law that directly impacts the grounds on which invalidity may be raised in IPR (such as the Supreme Court's expansion of obviousness in *KSR v. Teleflex*,[225] or the Federal Circuit's alterations to claim construction rules in *Phillips v. AWH Corp.*[226]), decisions impacting other conditions of patentability may have an indirect influence as well. For example, it has long been argued that patents vulnerable to patentable subject-matter challenges are disproportionately likely to also be vulnerable to anticipation and obviousness challenges.[227] Thus, the Supreme Court's substantial tightening of the rules for patentable subject matter in *Bilski v. Kappos*,[228] *Mayo Collaborative Services v. Prometheus Labs., Inc.*,[229] *Associated Molecular Pathology v. Myriad Genetics, Inc.*,[230] and *Alice Corp. v. CLS Bank*

225. 550 U.S. 398, 415 (2007) (rejecting the Federal Circuit's application of the "teaching, suggestion, or motivation" test as too "rigid").

226. 415 F.3d 1303, 1320 (Fed. Cir. 2005) (en banc) (criticizing earlier opinions that "placed too much reliance on extrinsic sources such as dictionaries, treatises, and encyclopedias and too little on intrinsic sources, in particular the specification and prosecution history").

227. *See* Bilski v. Kappos, 561 U.S. 593, 624 (2010) (Stevens, J., concurring) (noting that in crafting a test for abstractness there is "a risk of merely . . . seeing common attributes that track the familiar issues of novelty and obviousness that arise under other sections of the statute but are not relevant to § 101" (internal quotation marks omitted)); *see also* Michael Risch, *Everything is Patentable*, 75 TENN. L. REV. 591 (2008) (arguing that section 101 should be abandoned altogether as a check on patentability); Kristen Osenga, *Ants, Elephant Guns, and Statutory Subject Matter*, 39 ARIZ. ST. L.J. 1087, 1087 (2007) (arguing that rejecting software patents under section 101 is like "trying to kill an ant with an elephant gun" and is really a "mere[] prox[y] for . . . other statutory patentability requirements"); *but see* Brian J. Love, *Why Patentable Subject Matter Matters for Software*, 81 GEO. WASH. L. REV. ARGUENDO 1 (2010) (criticizing "recent federal circuit opinions [that] dismissively reject section 101 challenges as attacks that should have be made instead under sections 102, 103, and 112").

228. 561 U.S. 593, 603 (2010) (rejecting the "machine-or-transformation test as the sole test for what constitutes a [patentable] 'process'").

229. 566 U.S. 66, 78–79 (2012) (holding that the Patent Act's prohibition on patenting a law of nature "cannot be circumvented by attempting to limit the use of the formula to a particular technological environment," nor by adding to the claim "well-understood, routine, conventional activity previously engaged in by scientists who work in the field").

230. 569 U.S. 576, 590–94 (2013) (holding that isolated DNA segments are not patentable subject matter).

International[231] may have indirectly led in recent years to the abandonment of many applications (or shelving of many patents) that otherwise might have been of generally low quality.

In addition, many in the patent community perceive a general increase in the quality of USPTO examination in the past decade or so, particularly following the 2009 confirmation of David Kappos as Director.[232] During his tenure as Director of the USPTO, the size of the U.S. examining corps grew by 30 percent and the agency's backlog of unexamined applications began to shrink for the first time in many years.[233] While we are reluctant to ascribe these findings to any particular cause or causes, our age-related results are consistent with this hypothesis.

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231. 134 S. Ct. 2347, 2358 (2014) (holding that "the mere recitation of a generic computer cannot transform a patent-ineligible abstract idea into a patent-eligible invention").

232. *See Lawyers: David J. Kappos*, CRAVATH, SWAINE & MOORE LLP, https://www.cravath.com/dkappos/ (last visited Jan. 24, 2018) [https://perma.cc/8G9V-DHQZ] ("From August 2009 to January 2013, Mr. Kappos served as Under Secretary of Commerce and Director of the United States Patent and Trademark Office (USPTO). . . . As Director of the USPTO, he led the Agency in dramatically reengineering its entire management and operational systems as well as its engagement with the global innovation community.").

233. *See, e.g.*, Dennis Crouch, *USPTO Director Kappos Will Leave in January 2013*, PATENTLY-O (Nov. 26, 2012), https://patentlyo.com/patent/2012/11/uspto-director-kappos-will-leave-in-january-2013.html [https://perma.cc/FE5Q-5P4V] ("In an effort to eliminate the patent prosecution backlog, Kappos has led the charge to greatly increase the number of patent examiners over the past two years. During this time, the number of examiners has swelled to over 8,000—a more than 30% increase from two years before."); Joff Wild, *David Kappos Will Leave a Much Better USPTO than He Found*, IAM MEDIA (Nov. 26, 2012), http://www.iam-media.com/blog/detail.aspx?g=1725fe9a-50f2-4c7a-adef-6a8a12ececa4 [https://perma.cc/W4JZ-ANJY] ("[T]he real prize for the Director, and for the vast majority of USPTO users as well as its wider community of stakeholders, has been improved quality."); Ryan Davis, *Kappos a Tough Act to Follow as USPTO Director*, LAW360 (Nov. 27, 2012), https://www.law360.com/articles/396625/kappos-a-tough-act-to-follow-as-uspto-director [https://perma.cc/UFH2-VSD4] ("[H]is tenure has drawn wide acclaim from attorneys, who said it may be difficult to find a successor who can match his commitment to improving patent quality and open communication with the patent community.").

TABLE 5. Patent age

	N		Mean	*p*
Years earliest priority to first petition	2532	Never inst.	12.8 (671)	0.001***
		Instituted	13.6 (1861)	
		Denied inst.	13.1 (852)	0.064*
		Always inst.	13.5 (1680)	
Years filing to first petition	2532	Never inst.	9.0 (671)	0.088*
		Instituted	9.4 (1861)	
		Denied inst.	9.1 (852)	0.078*
		Always inst.	9.5 (1680)	
Years to grant first petition	2532	Never inst.	5.8 (671)	0.022**
		Instituted	6.4 (1861)	
		Denied inst.	5.9 (852)	0.017**
		Always inst.	6.4 (1680)	
Grant year	2532	Never inst.	2008.7 (671)	0.004***
		Instituted	2008.0 (1861)	
		Denied inst.	2008.6 (852)	0.005***
		Always inst.	2008.0 (1680)	

Note: Population of 2,532 patents subject to an inter partes review institution decision on the merits between September 16, 2012, and January 31, 2017. Some patents were the subject of multiple merit institution decisions and accordingly, "Never inst." versus "Instituted" compares the 671 petitioned patents never instituted on the merits to the 1,861 patents instituted at least once. "Denied inst." versus "Always inst." compares the 852 patents denied institution on the merits in at least one petition to the 1,680 patents always instituted. Institution rates with number of patents in parenthesis. Significant differences in institution rates designated: * for $p < .10$; **for $p < .05$; and *** for $p < .01$.

We also find significant correlations between institution and various metrics for the technology or technologies to which a patent relates. First, as shown below in Table 6, we find a significant correlation between institution and the number of U.S. technology classes assigned to petitioned patents. Interestingly, our findings on this point contrast with those of Mann and Underweiser. While they initially hypothesized (consistent with our findings) that the number of technology classes would be negatively correlated with validity—because an "invention spanning multiple classes would be a more ambitious invention and thus more susceptible of invalidation because of the multiplicity of technologies from which relevant art might be

found"[234]—they instead found a positive relationship, a fact that they chalked up to a large number of classes signifying either a thorough understanding of the technology by the USPTO or the cutting-edge nature of the claimed invention.[235] Consistent with Mann and Underweiser's original impulse, we suspect that our findings reflect that, to some degree, the number of USPCs an application is assigned proxies the technological breadth of the claimed invention, as well as the quantity of relevant prior art that may anticipate it.

That said, we fail to find a significant correlation between institution and CPC counts. Moreover, we find a significant correlation with respect to IPC counts that points in the opposite direction. At first, both results struck us as odd because the USPTO maintains a concordance between USPCs and both CPCs and IPCs.[236] However, neither concordance is a one-to-one match of classes. Indeed, some USPCs map to fifteen or more IPCs, while others map to none. As discussed in greater detail below, the negative correlation that we observe between institution and IPCs is driven by the relatively small number of IPCs assigned to software patents. Thus, we suspect that this correlation is principally an artifact of differing treatment of software by the two classification systems, perhaps reflecting the fact that "programs for computers" are not patentable in Europe.[237]

234. Mann & Underweiser, *supra* note 20, at 18.

235. *Id.*

236. The entire USPC-IPC concordance is available for download here: *USPC-IPC Correspondence*, FIGSHARE, https://figshare.com/articles/USPC-IPC_Correspondence/3502742 [https://perma.cc/9ED7-86EJ].

237. Article 52 of the European Patent Convention expressly excludes from the scope of patentable subject matter "schemes, rules and methods for performing mental acts, playing games or doing business, and programs for computers." Convention on the Grant of European Patents, Belg.-Turk., art. 52, Oct. 5, 1973, 1065 U.N.T.S. 255. As applied by the European Patent Office and European courts, this provision only prohibits patenting software-based inventions that are "solely" computer algorithms and, thus, do not make a "technical" contribution to a non-excluded field. *See, e.g.*, Aerotel Ltd. v. Telco Holdings Ltd. [2006] EWCA (Civ) 1371, [75]–[76], [2007] All E.R. 225, at [45]–[47] (Eng.) (holding that the relevant inquiry is whether the invention's "contribution [is] solely of excluded matter"; in other words, "whether the contribution is 'technical'").

TABLE 6. Patent technology classes

Number of tech classes	N		Mean	*p*
USPC	2532	Never inst.	3.8	0.009***
		Instituted	4.1	
		Denied inst.	3.8	0.014**
		Always inst.	4.1	
CPC	2532	Never inst.	9.7	0.639
		Instituted	9.9	
		Denied inst.	9.8	0.928
		Always inst.	9.8	
IPC	2532	Never inst.	4.8	0.056*
		Instituted	4.4	
		Denied inst.	4.8	0.013**
		Always inst.	4.3	

Note: Population of 2,532 patents subject to an inter partes review institution decision on the merits between September 16, 2012, and January 31, 2017. Some patents were the subject of multiple merit institution decisions and accordingly, "Never inst." versus "Instituted" compares the mean value of a trait for the 671 petitioned patents never instituted on the merits to the mean value for the 1,861 patents instituted at least once. "Denied inst." versus "Always inst." compares the mean value of a trait for the 852 patents denied institution on the merits in at least one petition to the mean for the 1,680 patents always instituted. Significant differences in means across institution categories designated: * for $p < .10$; **for $p < .05$; and *** for $p < .01$.

As shown below in Table 7, we find significant correlations between institution and a patent's classification as a "high tech," "business method," "medical," or "pharmaceutical" patent. While "high tech" patents were significantly more likely to be instituted (and thus appear to be of lower quality), the remaining categories were significantly less likely to be instituted (and thus appear to be of higher quality).

With respect to patents covering medical and pharmaceutical technology, our findings are consistent with conventional wisdom that such patents are of relatively high quality. One reason may be that pharmaceuticals are typically covered by just a handful of patents each.[238] In addition, pharmaceutical patents are likely to have clearer bounds than most other pa-

238. *See, e.g.*, Lisa Larrimore Ouellette, *How Many Patents Does It Take To Make a Drug? Follow-On Pharmaceutical Patents and University Licensing*, 17 MICH. TELECOMM. & TECH. L. REV. 299, 516–17 (2010) (reporting that pharmaceuticals are typically protected by just two to four patents per drug).

tents;[239] indeed, some claim specific molecules.[240] Relatively speaking, both facts tend to make it easier for applicants and examiners to locate and account for relevant prior art. Low patent density also tends to increase the value of individual pharmaceutical patents, which in turn may increase applicants' incentives to obtain high-quality patents. Whatever the precise cause, of all the data points that we analyzed, a patent's status as a pharmaceutical patent is one of the most impactful; 42 percent of challenged pharmaceutical patents were never instituted, compared to just 25 percent of all other patents.

Our findings with respect to "high tech" patents are, again, generally consistent with long-espoused complaints about the quality of patents covering computing and communications technology. In stark contrast to pharmaceuticals, many consumer electronics are plausibly covered by thousands of individual patents,[241] many of which were obtained reflexively to serve as small pieces of large defensive bulwarks rather than with assertion in mind.[242] In addition, there is good reason to believe that the USPTO may be ill equipped to locate important prior art to cutting-edge computing technology.[243]

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239. *See*, *e.g.*, JAMES BESSEN & MICHAEL J. MEURER, PATENT FAILURE: HOW JUDGES, BUREAUCRATS, AND LAWYERS PUT INNOVATORS AT RISK 107 (2008) (discussing "the comparatively clear boundaries of chemical (including pharmaceutical) patents"); Mark A. Lemley, *Software Patents and the Return of Functional Claiming*, 2013 WIS. L. REV. 905, 930 ("Unlike chemistry and biotechnology, where we have a clear scientific language for delineating what a patent claim does and doesn't cover, there is no standard language for software patents.").

240. *See, e.g.*, U.S. Patent No. 4,681,893 (filed July 21, 1987) (claiming atorvastatin calcium, the active ingredient in Lipitor).

241. For example, defensive patent aggregator RPX once placed the number of patents covering some aspect of a smartphone at approximately 250,000. RPX Corp., Registration Statement (Form S-1) 59 (Sept. 2, 2011), http://www.sec.gov/Archives/edgar/data/1509432/ 000119312511240287/ds1.htm (last visited Jan. 20, 2018) [https://perma.cc/FZY3-VV8W].

242. *See, e.g.*, Colleen V. Chien, *From Arms Race to Marketplace: The New Complex Patent Ecosystem and Its Implications for the Patent System*, 62 HASTINGS L.J. 297, 308–09 (2010) (defining "defensive patenting" as "the filing of patents in order to gain freedom to operate, for the specific purposes of maintaining patent peace, obtaining access to the technology of others, and neutralizing patent lawsuits" and noting that "[l]arge portfolios have spawned the development of other large portfolios").

243. *See* Julie E. Cohen & Mark A. Lemley, *Patent Scope and Innovation in the Software Industry*, 89 CALIF. L. REV. 1, 42–43 (2001) (noting that while "[t]he patent system presumes a finite, comprehensively indexed technical literature

That said, the subset of high tech patents that cover software and business methods stand out in our results as exceptions to the conventional wisdom. No other category of patent has been criticized more heavily in recent years than these two.[244] Yet, we fail to find a significant correlation between institution and software coverage and, more surprisingly still, find a significant *negative* correlation between institution and business method coverage. Thirty-eight percent of business method patents in our study were never instituted, close to the same rate that we observe for pharmaceutical patents.

We are reluctant, however, to interpret these results as indicating that business method patents are of high quality generally. Instead, we suspect that our findings reflect selection effects caused by the availability of CBM review, in which petitioners can argue that a patent fails to meet the standards of sections 101 and 112 of the Patent Act, in addition to sections 102 and 103. We hypothesize that parties seeking to challenge the validity of business method patents generally prefer to do so in a venue where they can argue that the patent falls outside the scope of patentable subject matter or fails to meet the requirements of section 112 due to unwarranted use of broad "functional" claim language.[245] If so, business method

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and relies on individual examiners to . . . search the relevant subliteratures," it is often the case that "software innovations . . . may be documented only via developer specifications or online FAQs [, and f]requently, the source code itself is never released at all"); Margo A. Bagley, *Internet Business Model Patents: Obvious by Analogy*, 7 MICH. TELECOMM. & TECH. L. REV. 253, 279 (2001) ("Commercial business models of the type that are being applied to the Internet, are likely, if anything, to be less well documented than financial methods. There simply is no real scientific literature on business models.").

244. *See, e.g.*, Lemley, *supra* note 239, at 928 ("Software patents are widely acknowledged as creating a large number of problems for the patent system."). In fact, many commentators have argued in favor of eliminating patent protection for software. *See* Pamela Samuelson, *Benson Revisited: The Case against Patent Protection for Algorithms and Other Computer Program-Related Inventions*, 39 EMORY L.J. 1025, 1135–36 (1990).

245. *See* Williamson v. Citrix Online, LLC, 792 F.3d 1339, 1349 (Fed. Cir. 2015) (en banc) (holding that a claim "recit[ing] function without reciting sufficient structure for performing that function" should be interpreted as a means-plus-function claim under section 112(f) and, thus, is invalid as indefinite under section 112(b) if the patent's specification fails to "disclose[ ] sufficient structure that corresponds to the claimed function" (internal quotation marks omitted)); *see also* Shong Yin, Williamson v. Citrix Online*: A Fundamental Shift and Return to Form in Means-Plus-Function Interpretation*, 31 BERKELEY TECH. L.J. 687, 707 (2016) ("The impact of the *Williamson II* decision has been expedient and immediate across the PTO and district courts. Over twenty PTAB decisions

patents challenged in inter partes review will be, relative to the broader population of business method patents, disproportionately less likely to be susceptible to challenges under sections 101 and 112 and thus *more* likely to have narrow claims that are limited to narrow applications in particular fields. Such claims, it seems safe to assume, would also be less susceptible to challenges on anticipation or obviousness grounds.[246]

TABLE 7. Patent technology areas

	N		Yes	No	*p*
High tech	1367 / 2532	Never inst.	23% (321)	30% (350)	0.000***
		Instituted	77% (1046)	70% (815)	
		Denied inst.	32% (437)	36% (415)	0.006***
		Always inst.	68% (930)	64% (750)	
Medical	423 / 2532	Never inst.	36% (151)	25% (520)	0.000***
		Instituted	64% (272)	75% (1589)	
		Denied inst.	42% (178)	32% (674)	0.000***
		Always inst.	58% (245)	68% (1435)	
Pharma	199 / 2532	Never inst.	42% (84)	25% (587)	0.000***
		Instituted	58% (115)	75% (1746)	
		Denied inst.	49% (98)	32% (754)	0.000***
		Always inst.	51%(101)	68% (1579)	
Software	599 / 2532	Never inst.	26% (158)	27% (513)	0.958
		Instituted	74% (441)	73% (1420)	
		Denied inst.	35% (208)	33% (644)	0.521
		Always inst.	65% (391)	67% (1289)	
Business methods	181 / 2532	Never inst.	38% (69)	26% (602)	0.000***
		Instituted	62% (112)	74% (1749)	
		Denied inst.	48% (87)	33% (765)	0.000***
		Always inst.	52% (94)	67% (1586)	

Note: Population of 2,532 patents subject to an inter partes review institution decision on the merits between September 16, 2012, and January 31, 2017. Some patents were the subject of multiple merit institution decisions and accordingly, "Never inst." versus "Instituted" compares the 671 petitioned patents never instituted on the merits to the 1,861 patents instituted at least once. "Denied inst." versus "Always inst." compares the 852 patents denied institution on the merits in at least one petition to the 1,680 patents always instituted. Institution rates with number of patents in parenthesis. Significant differences in institution rates designated: * for p < .10; **for p < .05; and *** for p < .01.

As shown below in Tables 8 and 9, we additionally find significant correlations between a patent's likelihood of institution and metrics of its length and complexity. While we fail to find a

and over twenty district court decisions have cited it.").

246. *See* sources cited *supra* note 227 (linking patent ineligibility to anticipation and obviousness).

significant relationship between claim count and institution,[247] we do nonetheless find significant correlations with respect to the word count of various parts of a patent.

Looking first at the length of a challenged patent's specification, we find a significant relationship between institution and both absolute and relative length measurements. Though one might expect patent length to serve as a proxy for the patentee's sophistication and resources, our findings are a bit more nuanced. Specifically, we find that while patent length *per claim* is negatively correlated with institution, absolute patent length is positively correlated with institution. That is, we find that never-instituted patents have fewer total words, shorter abstracts, and shorter specifications, but nonetheless have more words per claim than instituted patents. While, again, there may be various factors at play here, we suspect that these results reflect two effects. First, long patents with a large number of claims may tend to cover so much ground that they overwhelm examiners and prosecutors. Second, patents with specifications that are long relative to their claim count may tend to better disclose the patented technology, including relevant prior art. If so, such disclosure may assist examiners or reflect greater pre-filing diligence on the part of their applicants or prosecutors.

247. This finding itself may be noteworthy simply because it seems logical to assume that the more claims a patent has, the more opportunities there are for the applicant or examiner to make a mistake. *See* Mann & Underweiser, *supra* note 20, at 19 ("It is easy to suggest hypotheses that would relate the number of claims or complexity of the patent to validity. For example, a patent with more claims necessarily has more places in which mistakes could have been made.").

TABLE 8. Patent length

	N		Mean	*p*
Total number of claims	2532	Never inst.	28	0.101
		Instituted	30.1	
		Denied inst.	29.1	0.543
		Always inst.	29.8	
Number of independent claims	2532	Never inst.	3.9	0.319
		Instituted	4	
		Denied inst.	3.9	0.607
		Always inst.	4	
Word count entire patent	2532	Never inst.	14678	0.053*
		Instituted	16040	
		Denied inst.	15154	0.275
		Always inst.	15945	
Patent word count per claim	2532	Never inst.	1033	0.034**
		Instituted	820	
		Denied inst.	963	0.122
		Always inst.	833	
Abstract word count	2532	Never inst.	112	0.006***
		Instituted	118	
		Denied inst.	114	0.126
		Always inst.	117	
Specification word count	2532	Never inst.	12756	0.071*
		Instituted	13969	
		Denied inst.	13109	0.238
		Always inst.	13920	
Specification word count per independent claim	2532	Never inst.	5909	0.055*
		Instituted	5121	
		Denied inst.	5731	0.103
		Always inst.	5126	

Note: Population of 2,532 patents subject to an inter partes review institution decision on the merits between September 16, 2012, and January 31, 2017. Some patents were the subject of multiple merit institution decisions and accordingly, "Never inst." versus "Instituted" compares the mean value of a trait for the 671 petitioned patents never instituted on the merits to the mean value for the 1,861 patents instituted at least once. "Denied inst." versus "Always inst." compares the mean value of a trait for the 852 patents denied institution on the merits in at least one petition to the mean for the 1,680 patents always instituted. Significant differences in means across institution categories designated: * for $p < .10$; **for $p < .05$; and *** for $p < .01$.

Turning to the length of challenged patents' claims, we fail to find a significant correlation between institution and the

overall length of a patent's claim set. That said, as shown below in Table 9, we do find significance for both measures of the length of claim 1. As conventional wisdom has long suggested,[248] we find that instituted patents have significantly shorter individual claims, while patents that avoided institution have significantly longer claims.

TABLE 9. Claim length

	N		Mean	*p*
Total word count of all claims	2532	Never inst.	1473	0.440
		Instituted	1536	
		Denied inst.	1546	0.619
		Always inst.	1506	
Claim 1 word count	2532	Never inst.	169	0.074*
		Instituted	158	
		Denied inst.	171	0.005***
		Always inst.	156	
Claim 1 unique word count	2532	Never inst.	60.5	0.003***
		Instituted	57.5	
		Denied inst.	60.7	0.000***
		Always inst.	57.1	

Note: Population of 2,532 patents subject to an inter partes review institution decision on the merits between September 16, 2012, and January 31, 2017. Some patents were the subject of multiple merit institution decisions and accordingly, "Never inst." versus "Instituted" compares the 671 petitioned patents never instituted on the merits to the 1,861 patents instituted at least once. "Denied inst." versus "Always inst." compares the 852 patents denied institution on the merits in at least one petition to the 1,680 patents always instituted. Institution rates with number of patents in parenthesis. Significant differences in institution rates designated: * for p < .10; **for p < .05; and *** for p < .01.

C. Examination Intensity

Moving next to data that proxies the scrutiny each application received from the USPTO, we again find a number of significant correlations with institution. First, as shown below in Table 10, we find a significant correlation between institution and various categories of "backward citations." While one might expect institution to be negatively correlated with counts of such citations—for example, on the theory that more diligent

248. As discussed *supra* note 59 and accompanying text.

applicants and examiners will tend to find and review more prior art[249]—we actually find the opposite. We observe that never-instituted patents cited fewer pieces of prior art overall, had fewer prior art citations added by the examiner, and cited to fewer pieces of non-patent prior art.

Though perhaps initially surprising, these results are nonetheless consistent with findings by other researchers. In prior studies of patents examined by the EPO or challenged in EPO opposition procedures, both Lei and Wright[250] and Harhoff and Reitzig[251] found a negative correlation between prior art citations and patent quality. Accordingly, we suspect that these correlations tell us little about applicant and examiner diligence and instead reflect, to a much greater degree, the density and proximity of prior art to the patented invention. In other words, a large number of backward citations may simply reflect that the applicant and examiner correctly determined that the claimed invention was similar to a large number of pre-existing disclosures (some of which they may have inadvertently missed), while a small number of backward citations may similarly reflect that the applicant and examiner correctly concluded that the claimed invention is relatively unique and thus less likely to be anticipated or obvious.

249. *See, e.g.*, Kimberly A. Moore, *Xenophobia in American Courts*, 97 NW. U. L. REV. 1497, 1538 (2003) (hypothesizing that "patents that include more citations or more diverse citations are more likely to be valid").

250. Zhen Lei & Brian D. Wright, Why Weak Patents? Rational Ignorance or Pro-"Customer" Tilt? 38 (July 26, 2009) (unpublished manuscript), http://policydialogue.org/files/events/Lei_Wright_Why_Weak_Patents.pdf [https://perma.cc/R2BT-WB6M] ("[F]or the US patents in our sample, a higher number of *cited* prior patents is positively correlated with the failure at the EPO. Higher citations of prior art tend to indicate the weakness of a patent, rather than survival of a more rigorous examination, partly because issuing a US patent itself does not tell us much about its strength, as the applicant can always persist until the US examiner concedes.").

251. Harhoff & Reitzig, *supra* note 70, at 470 (finding "that there is also a significant relationship between backward citations and the incidence of opposition").

TABLE 10. Backward citations

	N		Mean	*p*
Total number of backward citations	2532	Never inst.	114	0.007***
		Instituted	142	
		Denied inst.	127	0.317
		Always inst.	138	
Added by examiner	2161	Never inst.	6.1	0.013**
		Instituted	7.1	
		Denied inst.	6.2	0.012**
		Always inst.	7.1	
Number of backward citations to foreign patent materials	2532	Never inst.	12.4	0.737
		Instituted	12.0	
		Denied inst.	12.4	0.733
		Always inst.	12.0	
Added by examiner	2211	Never inst.	0.14	0.160
		Instituted	0.18	
		Denied inst.	0.15	0.374
		Always inst.	0.18	
Number backward citations to non-patent literature	2352	Never inst.	34.5	0.002***
		Instituted	52.1	
		Denied inst.	44.0	0.438
		Always inst.	49.2	
Added by examiner	2258	Never inst.	0.64	0.427
		Instituted	0.54	
		Denied inst.	0.64	0.338
		Always inst.	0.52	

Note: Population of 2,532 patents subject to an inter partes review institution decision on the merits between September 16, 2012, and January 31, 2017. Some patents were the subject of multiple merit institution decisions and accordingly, "Never inst." versus "Instituted" compares the mean value of a trait for the 671 petitioned patents never instituted on the merits to the mean value for the 1,861 patents instituted at least once. "Denied inst." versus "Always inst." compares the mean value of a trait for the 852 patents denied institution on the merits in at least one petition to the mean for the 1,680 patents always instituted. Significant differences in means across institution categories designated: * for $p < .10$; **for $p < .05$; and *** for $p < .01$.

With respect to specific examination events, we find just a few relatively weak correlations. As shown below in Table 11, we fail to find a significant correlation between institution and the duration of the examination process, which we measure as the number of days between application filing and patent grant ("pendency"). Nor do we find a significant relationship between

institution and whether a patent's applicant conducted one or more examiner interviews,[252] amended its claims after a notice of allowance,[253] or gave notice of an intent to appeal some aspect of the examination.[254] Despite the intuition that longer, more eventful examination may correlate with more rigorous examination and thus higher-quality patents, our data suggests a lack of a clear relationship between the two. To the contrary, as our findings with respect to backward citations also attest, it may be the case that more unique inventions have less prior art and thus face a speedier path to issuance.

That said, we do find a modestly significant negative correlation between institution and both the number of times an application was the subject of a final rejection and the number of times the applicant filed an information disclosure statement (IDS). More rejections may correlate with more rigorous examination or, conversely, may indicate that the patent's claims are very close to the prior art. Similarly, more frequent disclosure of prior art by an applicant may correlate with applicant diligence or, conversely, may indicate that the applicant is seeking patent protection in a field crowded with prior art. All in all, our findings suggest that backward citations and the frequency of examination events are, at best, noisy proxies for quality.

Following Marco et al., we additionally examined the change in total number of claims and word count of claim 1 from the time that each patent's application was published to the time the application issued.[255] Our results here are a mixed bag. While we do observe a larger decrease in the number of claims from publication to grant among non-instituted patents, we do not find a significant correlation between institution and

252. *See* MPEP § 713 (9th ed. Rev. Aug. 2017) (setting forth procedures for requesting and conducting "interviews" (i.e., live video, phone, or in-person discussions between applicants and examiners)).

253. *See id.* § 714.16 (setting forth procedures by which an applicant can request a claim "amendment . . . before or with the payment of the issue fee" that "may be entered on the recommendation of the primary examiner . . . without withdrawing the application from issue"). Such amendments are often referred to as "Rule 312" amendments because they are authorized by 37 C.F.R. § 1.312 (2012). Our finding with respect to Rule 312 amendments contrasts with that of Mann and Underweiser, who found a strong, positive correlation between invalidity in Federal Circuit opinions and the use of Rule 312 amendments. Mann & Underweiser, *supra* note 20, at 29.

254. *See* MPEP § 1204 (9th ed. Rev. Aug. 2017) (setting forth procedures for appealing an application's rejection).

255. Marco et al., *supra* note 211.

the change in word count of claim 1.

TABLE 11. Prosecution pendency, event counts, and effect on claim count/length

	N		Mean	*p*
Pendency	2532	Never inst.	1166	0.281
		Instituted	1126	
		Denied inst.	1163	0.236
		Always inst.	1123	
Number of final rejections	2532	Never inst.	0.57	0.104
		Instituted	0.51	
		Denied inst.	0.57	0.067*
		Always inst.	0.50	
Number of non-final rejections	2532	Never inst.	1.33	0.701
		Instituted	1.31	
		Denied inst.	1.34	0.410
		Always inst.	1.31	
Number of IDSs filed	2532	Never inst.	3.5	0.260
		Instituted	3.2	
		Denied inst.	3.5	0.073*
		Always inst.	3.2	
Examiner interview	2532	Never inst.	0.37	0.568
		Instituted	0.34	
		Denied inst.	0.37	0.518
		Always inst.	0.34	
Amendment after notice of allowance	2532	Never inst.	0.15	0.316
		Instituted	0.17	
		Denied inst.	0.17	0.679
		Always inst.	0.16	
Notice of appeal	2532	Never inst.	0.10	0.776
		Instituted	0.10	
		Denied inst.	0.10	0.923
		Always inst.	0.10	
Change in number of claim 1 words	1709	Never inst.	35.9	0.206
		Instituted	23.1	
		Denied inst.	32.6	0.337
		Always inst.	23.4	
Change in number of claims	1709	Never inst.	-0.62	0.014**
		Instituted	-0.02	
		Denied inst.	-0.48	0.047**
		Always inst.	-0.02	

Note: Population of 2,532 patents subject to an inter partes review institution decision on the merits between September 16, 2012, and January 31, 2017. Some patents were the subject of multiple merit institution decisions and accordingly, "Never inst." versus "Instituted" compares the 671 petitioned patents never instituted on the merits to the 1,861 patents instituted at least once. "Denied inst." versus "Always inst." compares the 852 patents denied institution on the merits in at least one petition to the 1,680 patents always instituted. Institution rates with number of patents in parenthesis. Significant differences in institution rates designated: * for $p < .10$; **for $p < .05$; and *** for $p < .01$.

Turning next to data on patent families, we do not find a significant correlation between institution and the size of a patent's U.S. family. As shown below in Table 12, we do, however, find a significant negative correlation between institution and the number of foreign applications in a patent's family. In addition to capturing an applicant's confidence in the uniqueness and value of its invention, this finding may indicate that patent quality is enhanced when an invention is reviewed by multiple patent examiners employed by multiple patent offices. Prior and concurrent examinations may turn up additional prior art, limit applicants' ability to interpret claim language in certain ways,[256]and (at the very least) suggest that the invention is one viewed by its applicant as worth the cost of pursuing a bulwark of patent protection.

TABLE 12. Patent family

	N		Mean	*p*
Number of U.S. parent applications	2532	Never inst.	2.14	0.264
		Instituted	2.28	
		Denied inst.	2.21	0.690
		Always inst.	2.26	
Number of U.S. child applications	2532	Never inst.	2.46	0.751
		Instituted	2.38	
		Denied inst.	2.46	0.682
		Always inst.	2.37	
Number of foreign family members	2532	Never inst.	3.52	0.020**
		Instituted	2.97	
		Denied inst.	3.52	0.004***
		Always inst.	2.91	

Note: Population of 2,532 patents subject to an inter partes review institution decision on the merits between September 16, 2012, and January 31, 2017. Some patents were the subject of multiple merit institution decisions and accordingly, "Never inst." versus "Instituted" compares the mean value of a trait for the 671 petitioned patents never instituted on the merits to the mean value for the 1,861 patents instituted at least once. "Denied inst." versus "Always inst." compares the mean value of a trait for the 852 patents denied institution on the merits in at least one petition to the mean for the 1,680 patents always instituted. Significant differences in means across institution categories designated: * for $p < .10$; **for $p < .05$; and *** for $p < .01$.

That said, despite observing a significant effect associated with foreign examination generally, we fail to detect a clear,

256. *See, e.g.*, Therasense, Inc. v. Becton, Dickinson & Co., 864 F. Supp. 2d 856, 869 (N.D. Cal. 2012) (holding that a patent-in-suit is unenforceable due to inequitable conduct stemming from failure to disclose to the USPTO briefs that were filed with the EPO during prosecution of a related application).

significant link between U.S. patent quality and concurrent examination by any of the world's next four most popular patent offices.[257] Though it is often said that at least the EPO provides more thorough examination than the USPTO,[258] we find little evidence that additional scrutiny from any particular foreign patent office improves U.S. patent quality.

TABLE 13. International patent family

	N		Yes	No	*p*
EPO family member	868/2100	Never inst.	27% (234)	26% (321)	0.651
		Instituted	73% (634)	74% (911)	
		Denied inst.	36% (310)	33% (406)	0.191
		Always inst.	64% (558)	67% (826)	
JPO family member	645/2100	Never inst.	28% (180)	26% (375)	0.309
		Instituted	72% (465)	74% (1080)	
		Denied inst.	36% (230)	33% (486)	0.319
		Always inst.	64% (415)	67% (969)	
KIPO family member	286/2100	Never inst.	29% (84)	26% (471)	0.221
		Instituted	71% (202)	74% (1343)	
		Denied inst.	40% (115)	33% (601)	0.022**
		Always inst.	60%(171)	67% (1213)	
SIPO family member	434/2100	Never inst.	28% (120)	26% (435)	0.541
		Instituted	72% (314)	74% (1231)	
		Denied inst.	35% (152)	34% (564)	0.650
		Always inst.	65% (282)	66% (1102)	

Note: Population of 2,532 patents subject to an inter partes review institution decision on the merits between September 16, 2012, and January 31, 2017. Some patents were the subject of multiple merit institution decisions and accordingly, "Never inst." versus "Instituted" compares the 671 petitioned patents never instituted on the merits to the 1,861 patents instituted at least once. "Denied inst." versus "Always inst." compares the 852 patents denied institution on the merits in at least one petition to the 1,680 patents always instituted. Institution rates with number of patents in parenthesis. Significant differences in institution rates designated: * for p < .10; **for p < .05; and *** for p < .01.

D. Post-Grant Characteristics

The final group of bivariate comparisons that we report explores correlations with patent characteristics acquired after is-

257. *See* WORLD INTELL. PROP. ORG., WIPO IP FACTS AND FIGURES 11 (2016), http://www.wipo.int/edocs/pubdocs/en/wipo_pub_943_2016.pdf [https://perma.cc/39V3-4HRM] ("Just five IP offices account for more than four-fifths of all patent filings.").

258. *See* Chien, *supra* note 3, at 15 ("Industry surveys conducted in 2010, 2011, 2012, and 2015-2016 have each consistently found the EPO to have the highest ratings among the five leading Patent Offices around the world.").

suance. Though well removed from the actual prosecution of challenged patents, these data points may nonetheless reveal how other patent-system participants assessed the patent's quality at various times post-issuance.

First, we consider "forward citations," that is, citations to the challenged patent that appear on the face of subsequent patents. As shown below in Table 14, we do not find a significant correlation between forward citations and institution. This result is noteworthy because forward citations are generally considered the single most important proxy for patent value—usually under the theory that such citations indicate "that an innovation has contributed to the development of subsequent invention."[259] Consistent with this theory, one might expect petitioned patents with more forward citations to pre-date more of the art in a particular field and, thus, possess claims that are more likely to be novel and nonobvious. However, we find no evidence supporting this hypothesis.

TABLE 14. Forward citations

	N		Mean	*p*
Number of forward citations	2532	Never inst.	48.8	0.584
		Instituted	51.4	
		Denied inst.	51.0	0.933
		Always inst.	50.6	

Note: Population of 2,532 patents subject to an inter partes review institution decision on the merits between September 16, 2012, and January 31, 2017. Some patents were the subject of multiple merit institution decisions and accordingly, "Never inst." versus "Instituted" compares the mean value of a trait for the 671 petitioned patents never instituted on the merits to the mean value for the 1,861 patents instituted at least once. "Denied inst." versus "Always inst." compares the mean value of a trait for the 852 patents denied institution on the merits in at least one petition to the mean for the 1,680 patents always instituted. Significant differences in means across institution categories designated: * for p < .10; **for p < .05; and *** for p < .01.

Turning next to each patent's ownership history, we do find a number of significant results. As shown below in Tables 15 and 16, we find that instituted patents are more likely to have changed hands and more likely to have changed hands frequently.

259. Jean O. Lanjouw & Mark Schankerman, *Characteristics of Patent Litigation: A Window on Competition*, 32 RAND J. ECON. 129, 137 (2001).

TABLE 15. Reassignment history

	N		Yes	No	*p*
Reassigned?	1417 / 2532	Never inst.	25% (348)	29% (323)	0.014**
		Instituted	75% (1069)	71% (792)	
		Denied inst.	32% (458)	30% (394)	0.117
		Always inst.	68% (959)	70% (721)	
Three or more reassignments?	497 / 2532	Never inst.	23% (112)	27% (559)	0.027**
		Instituted	77% (385)	73% (1476)	
		Denied inst.	31% (154)	34% (698)	0.169
		Always inst.	69% (343)	66% (1337)	

Note: Population of 2,532 patents subject to an inter partes review institution decision on the merits between September 16, 2012, and January 31, 2017. Some patents were the subject of multiple merit institution decisions and accordingly, "Never inst." versus "Instituted" compares the 671 petitioned patents never instituted on the merits to the 1,861 patents instituted at least once. "Denied inst." versus "Always inst." compares the 852 patents denied institution on the merits in at least one petition to the 1,680 patents always instituted. Institution rates with number of patents in parenthesis. Significant differences in institution rates designated: * for p < .10; **for p < .05; and *** for p < .01.

TABLE 16. Reassignment count

	N		Mean	*p*
Reassignment count	2532	Never inst.	1.2	0.003***
		Instituted	1.4	
		Denied inst.	1.3	0.191
		Always inst.	1.4	

Note: Population of 2,532 patents subject to an inter partes review institution decision on the merits between September 16, 2012, and January 31, 2017. Some patents were the subject of multiple merit institution decisions and accordingly, "Never inst." versus "Instituted" compares the mean value of a trait for the 671 petitioned patents never instituted on the merits to the mean value for the 1,861 patents instituted at least once. "Denied inst." versus "Always inst." compares the mean value of a trait for the 852 patents denied institution on the merits in at least one petition to the mean for the 1,680 patents always instituted. Significant differences in means across institution categories designated: * for p < .10; **for p < .05; and *** for p < .01.

Also, as shown below in Table 17, we find significant positive correlations between a patent's institution and its ownership by an NPE or PAE—a finding that may reflect a tendency for NPEs and PAEs to choose patents with broad claims that are more likely to cover both popular products and the prior art. While reassignment might plausibly serve as a proxy for a number of things, we suspect that it most likely reflects whether challenged patents were sold on the secondary market

for monetization purposes.[260] We explore this relationship further below.

TABLE 17. Current owner type

	N		Yes	No	*p*
Individual	57 / 2532	Never inst.	42% (24)	26% (647)	0.010**
		Instituted	58% (33)	74% (1828)	
		Denied inst.	46% (26)	33% (826)	0.065*
		Always inst.	54% (31)	67% (1649)	
NPE	1034 / 2532	Never inst.	22% (224)	30% (447)	0.000***
		Instituted	78% (810)	70% (1051)	
		Denied inst.	31% (316)	36% (536)	0.007***
		Always inst.	69% (718)	64% (962)	
PAE	788 / 2532	Never inst.	19% (149)	30% (522)	0.000***
		Instituted	81% (639)	70% (1222)	
		Denied inst.	29% (228)	36% (624)	0.001***
		Always inst.	71%(560)	64% (1120)	
University	77 / 2532	Never inst.	34% (26)	26% (645)	0.150
		Instituted	66% (51)	74% (1810)	
		Denied inst.	35% (27)	34% (825)	0.807
		Always inst.	65% (50)	66% (1630)	

Note: Population of 2,532 patents subject to an inter partes review institution decision on the merits between September 16, 2012, and January 31, 2017. Some patents were the subject of multiple merit institution decisions and accordingly, "Never inst." versus "Instituted" compares the 671 petitioned patents never instituted on the merits to the 1,861 patents instituted at least once. "Denied inst." versus "Always inst." compares the 852 patents denied institution on the merits in at least one petition to the 1,680 patents always instituted. Institution rates with number of patents in parenthesis. Significant differences in institution rates designated: * for p < .10; **for p < .05; and *** for p < .01.

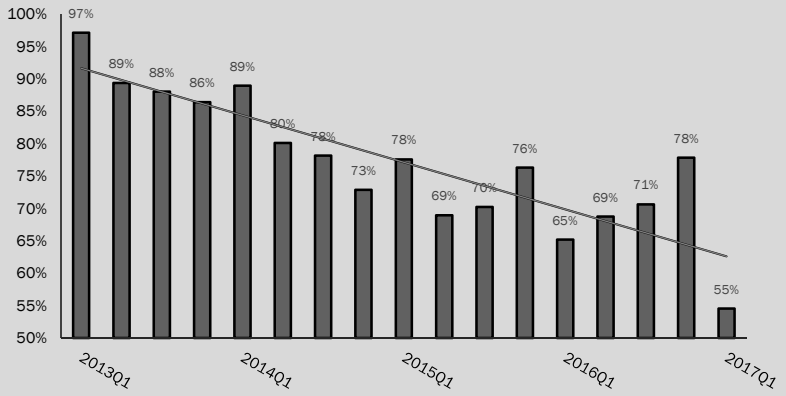
Finally, we note the potential importance of the timing of each patent's challenge. To gauge whether PTAB panels have become more or less strict over time, we grouped all challenged patents by the date of their first institution decision on the merits and calculated quarterly "first-time institution rates." As shown below in Figure 2, we observe a rather large, significant drop in that rate over time.[261] While such a drop does not

260. To explore the relationship between reassignments and NPE-ownership, we regressed the probability that a petitioned patent was never instituted on three variables: NPE-ownership and both reassignment measures. In that three-variable regression, NPE- and PAE-ownership remained highly significant, while reassignment lost significance—a finding that strongly suggests that our reassignment-related correlations are driven by ownership-type.

261. We find a significant nine-month gap (p = 0.000) between the mean quarter of first institution decision among instituted patents and the mean quarter of first institution decision among never-instituted patents.

necessarily indicate a change in PTAB institution standards—for example, petitioners may have initially challenged especially weak patents—our multivariate results (discussed below) show that this decline persists even when controlling for the other significant data points we study.[262]

FIGURE 2: First-time institution rate by quarter



Note: Quarterly first-time institution rates calculated using the population of 2,532 patents subject to an inter partes review institution decision on the merits between September 16, 2012, and January 31, 2017. Linear trend included with an average 1.8 percent decline in first-time institution rate each quarter. Chi-square test rejected the null that the first-time institution rate has not declined over the time period (p = 0.000).

V. MULTIVARIATE ANALYSIS

While the bivariate results reported above are interesting in their own right, many of the patent traits studied are intercorrelated. To shed more light on the driving forces behind our results, we ran three series of probit regressions to determine which of the predictors identified *supra* in Part IV survive multivariate analysis.[263] First, we examined a single regression of twenty-one of the most promising variables across our

262. Later in our multivariate analysis, we find that the quarterly trend is a significant predictor of institution with the addition of one quarter predicting a 0.7 percent decrease in the chance of institution. Accordingly, the IPR institution rate appears to have declined over time even controlling for the various patent characteristics we study.

263. We report the marginal effects for each independent variable using Stata's *dprobit* command.

population of patents.[264] Next, we analyzed a series of similar regressions that additionally compare combinations of the four examiner characteristics. Finally, we calculated a series of regressions across subsets of petitioned patents. In this third regression, we also tested whether additional variables that did not appear significant above might nonetheless show significance in smaller subsets of challenged patents.

A. Twenty-One Variables, Across All Patents

For the first of our multivariate regressions, we selected a set of twenty-one variables for further analysis. We selected these with two considerations in mind: first, their significance in the bivariate regressions reported above, and second, their representativeness of the various categories of data that we collected.[265] The variables that we selected are listed below in the first column of Table 18, which also presents the results of a probit regression of all twenty-one variables across 2,527 challenged patents. While each variable was significantly correlated with institution in the bivariate analysis described above, we find that many lose their significance when we control for the other twenty. That said, many others retain their significance and, thus, stand out to us as strong predictors of patent quality.

Beginning with applicant characteristics, we find that while small entity status remains significant, initial assignment of the petitioned patent to an individual is no longer a significant predictor of institution. Controlling for the other twenty variables included in Table 18, petitioned small-entity patents remain about five percent more likely to be instituted at least once. With respect to the applicant's choice of prosecution counsel, we see that petitioned patents prosecuted by large firms remain significantly more likely (about six percent) to avoid institution. That said, controlling for all twenty other variables, prosecution by a solo practitioner loses its significance, likely due to its correlation with small-entity status.[266]

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264. With the exception of five patents for which we lack examiner-related data.

265. We also avoided including highly correlated or collinear variables from the same group in the same regression.

266. However, in an unreported regression that omits the large firm variable from Table 18, we find that prosecution by a solo practitioner is also a significant

Turning next to the characteristics of petitioned patents' examiners, we find significance with respect to the allowance rate of examiners' art units and the differential between examiners' allowance rates and that of the art units (though the latter is significant only at a 90 percent confidence level). We investigate the relationship between institution- and examiner-related variables in greater detail below.

Moving on to characteristics of the petitioned patents themselves, we first make the noteworthy finding that neither of the two patent age-related variables—time from priority to first petition and grant year—remains significant. Despite the high negative correlation between these two age characteristics, including both in our regressions is not the source of lost significance. Rather, additional correlation tests revealed that both variables are highly correlated with other, stronger predictors of institution, including examiner characteristics, backward citations, technology type, and PAE ownership.

Interestingly, we also fail to find significant relationships between institution and "high tech" or "pharmaceutical" subject matter.[267] As revealed below in Table 19, specification 2, pharmaceutical patents are significantly less likely to be instituted when not controlling for both examiner and art unit allowance rates. Thus, the lack of pharmaceutical significance in Table 18 is due to the strong negative correlation between pharmaceutical coverage and both examiner allowance rate and art unit allowance rate.[268] High tech subject matter is also strongly correlated with several other variables, including examiner experience, examiner allowance rate, patent age, and PAE ownership.[269]

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predictor of institution, with solo-prosecuted patents 5 percent more likely to be instituted than other patents (p = 0.049). Thus, prosecutor size appears to be a robust proxy for patent quality.

267. In similar unreported regressions, we substituted "medical" subject matter for "pharmaceutical" subject matter, and separately substituted "software" subject matter for "high tech" subject matter. Neither swap reversed the lack of significance we report here.

268. The mean allowance rate among examiners of challenged pharmaceutical patents was 55 percent, while the mean allowance rate among examiners of all other challenged patents was 79 percent (p = 0.000). Similarly, the mean allowance rate among art units to which challenged pharmaceutical patents were assigned was 57 percent, while the mean allowance rate among all other art units to which challenged patents were assigned is 75 percent (p = 0.000).

269. Almost all PAE patents are high tech patents, and as we have already discussed, PAE patents are significantly more likely to be instituted. Moreover,

While our technology classification variables lose most of their explanatory power in our multivariate regressions, the number of USPCs assigned to a patent by the USPTO remains statistically significant. As shown below in Table 18, the marginal effect of one additional USPC is a 0.6 percent increase in the chance of institution.[270] We likewise continue to see a significant relationship between institution and both length-related variables that we included. The number of unique words in claim 1, in particular, appears to be a robust proxy for quality, with a marginal effect of 10 additional words reducing the risk of institution by 1 percent. For word count per claim, our regression reveals a far more modest marginal effect: a decrease of 1,000 words per claim leads to just a 1 percent increase in the probability of institution.[271]

Moving to prosecution-related variables, we continue to see modest effects. First, while the total number of backward citations remains a significant positive predictor of institution, the magnitude of the effect is small, with an additional 100 citations associated with just a 1.5 percent increase in the probability of institution.[272] We likewise find weak evidence that the

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the mean allowance rate among examiners of challenged high tech patents was 82 percent, while the mean allowance rate among examiners of all other challenged patents was 71 percent ($p = 0.000$).

270. In an unreported set of specifications in which we substituted IPC count for USPC count, IPC count was not a significant predictor of institution ($p = 0.125$).

271. In an unreported set of specifications, we found that specification-word-count-per-independent-claim also has a statistically significant, negative relationship with institution. For example, when we substituted specification-word-count-per-independent-claim for total-word-count-per-claim in specification 3 of Table 19, we found that a decrease of 1,000 words per independent claim in the specification is associated with a 0.27 percent increase in the probability of institution ($p = 0.010$). In unreported specifications, we also tested the three "absolute" length variables mentioned above—total word count, total specification word count, and total abstract word count. None of these was a significant predictor of institution, however.

272. In unreported regressions, we also found that reverse citations to NPL was a positive, statistically significant predictor of institution. In fact, the magnitude of this variable's impact (in an alternative version of Table 19 specification 3) was about twice that of total reverse citations, with an additional 100 citations to NPL leading to a more than 3 percent increase in the probability of institution (i.e., a coefficient of -0.00033 with $p = 0.001$). In yet other unreported regressions similar to those in Table 19, we found that the variable "reverse citations added by the examiner" is a positive, but not statistically significant, predictor of institution. In an alternative version of Table 19 specification 3, the marginal effect for "reverse citations added by the examiner" was -0.0018 ($p = 0.085$).

number of IDS filings in a patent's prosecution history is a useful predictor of institution. While the marginal effect is a 0.36 percent decrease in the chance of institution per additional IDS filing, it just misses significance at the 90 percent confidence level (p = 0.104).[273] Finally, controlling for all twenty other variables, we fail to find significance in any variable related to family size.

We do find, however, significant relationships between institution and acquired patent characteristics. First, we continue to see (with our "Quarter First Institution Decision" variable) that patents subject to institution decisions more recently are less likely to have been instituted, which suggests either that the PTAB has become easier on petitioned patents over time or that we have failed to capture in our variables one or more significant metrics that have varied over time. We also continue to see statistically significant results for patents owned by PAEs. Even after controlling for all of the other quality-related characteristics listed in Table 18, PAE patents remain nearly 8 percent more likely than all other patents to have been instituted.[274]

273. In an unreported regression, we substituted the number of final rejections for the number of IDS filings and found rejection count to be entirely insignificant ($p > 0.600$).

274. In unreported regressions, we found that NPE ownership is likewise a statistically significant predictor of institution. Of the two, PAE ownership is the stronger predictor. Substituting NPE for PAE in Table 18 yields a coefficient of -0.051 (p = 0.016). As discussed above, PAE ownership is also highly correlated with all three of our reassignment history variables shown in Tables 15 and 16. We tested this relationship in three unreported regressions that each added a reassignment-related variable to Table 18. In each of these regressions, PAE ownership remained significant, while each reassignment variable lost its significance. Accordingly, our reassignment history variables appear to lack significance independent of PAE ownership.

TABLE 18. Probit estimation of the likelihood a petitioned patent was never instituted.

	Marginal effect	Robust standard error
Applicant, prosecutor, and examiner characteristics		
Small entity	-0.050**	(0.020)
Individual assignee	-0.011	(0.032)
Large firm prosecutor	0.063***	(0.019)
Solo firm prosecutor	-0.023	(0.027)
Number of applications examiner reviewed	-0.000018	(0.000013)
Art Unit allowance rate	-0.299***	(0.096)
Allowance rate differential (relative to art unit)	-0.145*	(0.082)
Patent characteristics		
Quarter first institution decision	0.0078***	(0.0023)
Years earliest priority to first petition	-0.0028	(0.0025)
Grant year	-0.0037	(0.0028)
Number of U.S. patent classes	-0.0063**	(0.0031)
High tech	0.010	(0.021)
Pharma	0.062	(0.042)
Word count per claim	0.000011**	(0.00005)
Unique word count of claim 1	0.0013***	(0.0004)
Examination intensity		
Number of backward citations	-0.00015***	(0.00004)
Number of IDSs filed	0.0036	(0.0022)
Number of foreign family members	-0.0013	(0.0020)
Post-grant characteristics		
Reassigned?	-0.008	(0.019)
Individual owned	0.172**	(0.074)
PAE owned	-0.076***	(0.021)
Log-likelihood	-1390	
Observations	2527	

Note: Population of 2,527 patents (with complete examiner data) subject to an inter partes review institution decision on the merits between September 16, 2012, and January 31, 2017. Some patents were the subject of multiple merit institution decisions and accordingly, "Never Instituted" versus "Instituted" compares the 671 petitioned patents never instituted on the merits to the 1,861 patents instituted at least once. Marginal effects reported with discrete change of dummy variables from 0 to 1. Robust standard errors included in parenthesis. * p < .10; ** p < .05; and *** p < .01.

B. Examiner Characteristics

Among the variables that remain significant in the regression described above, patent examiner characteristics stand out as perhaps the most intriguing. Unfortunately, they are also the most highly correlated—and, in the case of allowance rates, clearly collinear. To investigate these variables further, we conducted a series of multivariate regressions, five of which are shown below in Table 19, to compare various combinations of four traits of petitioned patents' examiners: the total number of applications they have examined, their allowance rates, their

art units' allowance rates, and the differential between these latter two rates.[275] Of these four variables, our results strongly suggest that examiner allowance rate is the most important.

First, we began by comparing the marginal effects of examiner allowance rate and art unit allowance rate.[276] Though we saw above that both have a significant positive correlation with institution, the two variables are clearly correlated to some extent because art units with higher overall allowance rates will naturally tend to be staffed with many examiners that have relatively high individual allowances rates. Before comparing the two variables together in a single regression, we first measured the marginal effect of each variable in a nineteen-variable regression that omits the other.[277] The regression that included only examiner allowance rate returned a coefficient of -0.248 (p = 0.000), indicating that a 10 percent increase in an examiner's allowance rate leads to a 2.5 percent decline in a probability that a patent examined by that individual will never be instituted. The regressions that included only art unit allowance rate returned a coefficient of -0.260 (p = 0.002), indicating quite similarly that a 10 percent increase in an art unit's allowance rate is associated with a 2.6 percent drop in the probability that a petitioned patent from that unit will never be instituted. Thus, our findings suggest that decreases in either examiner allowance rates or art unit allowance rates will improve patent quality.[278] When we include both variables together in a single regression, as shown below in Specification 1, the results suggest that examiner allowance rate is the stronger of the two, with a coefficient of -0.193 (p = 0.009) compared to a coefficient of -0.149 (p = 0.111) for art unit allowance rate. These results suggest that, when controlling for

275. In Table 18, we included allowance rate differential and art unit allowance rate, but omitted examiner allowance rate because the latter is simply the sum of the first two variables. In other words, each of the three variables is perfectly collinear with the other two in combination. *See supra* Table 18.

276. That is, we ran two 20-variable regressions that included only one of our examiner characteristics at a time. These two regressions are not shown below in Table 19, but are otherwise identical to those shown below in Table 19. *See infra* Table 19.

277. These two regressions are not shown in Table 19. *See infra* Table 19.

278. One may rightly question whether a 10 percent increase or decrease in the allowance rate is feasible, but our data suggests that it is. We find a standard deviation of 15.8 percent among examiner allowance rates and a standard deviation of 12.6 percent among art unit allowance rates.

art unit allowance rate, examiner allowance rate continues to have a significant impact (but not vice versa).[279]

Looking next at examiner experience, we see from Specifications 2, 4, and 5 that the number of applications an examiner has handled in his or her career is a statistically significant predictor of institution, both by itself and when controlling for art unit allowance rates or the differential between examiner and art unit allowance rates. The marginal effect of experience is large as well, with each 1,000 additional applications assigned to an examiner leading to a 2.5 percent increase in the probability that his or her patents will be instituted.[280] However, comparing Specifications 2 and 3, it appears that much of the significance of examiner experience is driven by examiner allowance rate and not the other way around. Shifting from Specification 2 to Specification 3, we find that examiner experience is not significant when controlling for examiner allowance rate (p = 0.167 in Specification 3). Thus, individual examiner generosity is highly correlated with examiner experience.

279. Compare Specification 2 to Specifications 4 and 5.

280. As with allowance rates, the variation in examiner experience is large with a standard deviation of 823 applications. *Accord* Cockburn et al., *supra* note 20, at 39 ("We see that although the average examiner in our sample has a lifetime experience of over 2,000 patents, a large number are associated with over 4,000 patents, with a few outliers of over 7,000 patents.").

Table 19. Probit estimation of the likelihood a petitioned patent was never instituted (examiner-related variables)

	1		2		3		4		5	
Applicant, Prosecutor and Examiner Characteristics:										
Small Entity	-0.050**	(0.020)	-0.045**	(0.020)	-0.048**	(0.020)	-0.049**	(0.020)	-0.466***	(0.124)
Individual Assignee	-0.010	(0.032)	-0.014	(0.032)	-0.011	(0.032)	-0.012	(0.032)		
Large Firm Prosecutor	0.063***	(0.019)	0.066***	(0.019)	0.064***	(0.019)	0.064***	(0.019)	0.0009	(0.0034)
Solo Firm Prosecutor	-0.025	(0.027)	-0.025	(0.027)	-0.024	(0.027)	-0.024	(0.027)	0.0021	(0.075)
No. of applications examiner			-0.000032***	(0.000012)	-0.000018	(0.000013)	-0.000027**	(0.000012)	0.0070**	(0.0034)
Examiner's overall allowance rate	-0.193***	(0.074)			-0.203***	(0.075)				
Art Unit allowance rate	0.149	(0.094)					-0.227***	(-0.000019)	0.000016**	(-0.000007)
Allowance rate differential (rel. to Art Unit)									-0.0005	(0.0008)
Patent Characteristics:										
Quarter First Institution Decision	0.0080***	(0.0023)	0.0074***	(0.0022)	0.0075***	(0.0022)	0.0078***	(0.0023)	-0.00011**	(0.00005)
Years earliest priority to first petition	-0.0031	(0.0025)	-0.0022	(0.0025)	-0.0023	(0.0025)	-0.0029	(0.0025)	-0.0006	(0.0018)
Grant year	-0.0036	(0.0028)	-0.0010	(0.0026)	-0.0026	(0.0027)	-0.0032	(0.0027)	0.0002	(0.0038)
Num. of US Patent Classes	-0.0061**	(0.0031)	-0.0062**	(0.0031)	-0.0063**	(0.0031)	-0.0062**	(0.0031)	0.016	(0.019)
High Tech	0.019	(0.020)	-0.008	(0.020)	0.007	(0.021)	0.003	(0.021)	-0.016***	(0.005)
Pharma	0.059	(0.041)	0.113***	(0.041)	0.074*	(0.042)	0.078**	(0.041)		
Word Count / Claim	0.000011**	(0.000005)	0.000012**	(0.000005)	0.000012**	(0.000005)	0.000011**	(0.000005)	0.00020	(0.00014)
Unique Word Count of Claim 1	0.0013***	(0.0004)	0.0014***	(0.0004)	0.0013***	(0.0004)	0.0014***	(0.0004)	-420	
Examination Intensity									829	
Num. Backward Citations	-0.00015***	(0.00004)	-0.00016***	(0.00004)	-0.00015***	(0.00004)	-0.00015***	(0.00004)		
Num. IDS Filed	0.0035	(0.0022)	0.0042*	(0.0022)	0.0036	(0.0022)	0.0040*	(0.0022)		
Num. Foreign Family Members	-0.0014	(0.0020)	-0.0011	(0.0020)	-0.0013	(0.0020)	-0.0013	(0.0020)		
Post-Grant Characteristics										
Reassigned?	-0.007	(0.019)	-0.007	(0.019)	-0.006	(0.019)	-0.009	(0.019)		
Individual Owned	0.173**	(0.073)	0.180***	(0.074)	0.172**	(0.073)	0.176**	(0.074)		
PAE Owned	-0.073***	(0.021)	-0.079***	(0.021)	-0.076***	(0.021)	-0.077***	(0.021)		
Log-likelihood	-1390		-1394		-1390		-1390			
Observations	2527		2527		2527		2527			

Note: Population of 2,527 patents (with complete examiner data) subject to an inter partes review institution decision on the merits between September 16, 2012, and January 31, 2017. Some patents were the subject of multiple merit institution decisions and accordingly, "Never Instituted" versus "Instituted" compares the 671 petitioned patents never instituted on the merits to the 1,861 patents instituted at least once. Marginal effects reported with discrete change of dummy variables from 0 to 1. Robust standard errors included in parenthesis. * p < .10; ** p < .05; and *** p < .01.

C. Determinants of Institution by Subset of the Population of Petitioned Patents

Next, we present a series of regressions to examine the significance of variables in the context of patents from particular industry and technology groups. We do so for two reasons. First, different industries often have different visions of the ideal patent system, and we believe that these differences are justified in part due to well-documented industry and technology differences in the efficacy of patents.[281] Separating our analysis for patents related to particular industries or technologies may reveal that these differences lead to variation among proxies for patent quality. Second, in addition to observing whether this leads to changes in effect size and significance among variables included in the regressions above, this allows us to test whether other variables that failed to show significance in the population-wide bivariate regressions presented *supra* in Part VI might nonetheless have significant effects in one or more subpopulations of challenged patents.

The specifications shown below in Table 20 report regression results for six different groups of patents: (1) those prosecuted by large firms, (2) those covering medical technology, (3) those covering pharmaceutical technology, (4) those covering software, (5) those owned by NPEs, and (6) those owned by PAEs.[282] Overall, what we observe is consistent with our findings above. Variables related to examiner grant rate, number of technology classes, and number of backward citations remain significant and similarly correlated in most subpopulations.

There are, however, a few noteworthy variations across these groups. First, as shown below in Specifications 5 and 6, the sign of the coefficient for unique-word-count-of-claim-1 is flipped for NPE- and PAE-owned patents (though neither is significant), as is the sign of the overall-word-count-per-claim coefficient for PAE patents. In short, while longer claims appear to be of higher quality generally, the opposite may be true of patents owned by monetizing entities. While this finding could have a number of explanations, it may suggest, at

281. *See supra* notes 240–244 and accompanying text.

282. In Appendix Table A.1, we report these same specifications but for the probability that the patents in each group would be denied institution rather than never instituted. *See infra* Table A.1.

least in part, a disproportionate preference among monetizers for patents that are "skillfully drafted" in ways that increase word count while only superficially narrowing claim scope.[283]

Second, we find that the negative relationship noted in Table 6 between institution and IPC counts is significant in these specifications only for software patents and patents owned by NPEs. We further find that the sign of the coefficient actually reverses in the cohort of patents prosecuted by large law firms. These findings suggest to us that the significance of IPCs primarily reflects the differing classification methodologies for software-related technologies employed by the USPTO and WIPO.[284]

Third, we find that contrary to our observations above, the number of backward citations added by the examiner to a challenged patent has a negative and nearly significant ($p = 0.112$) correlation with institution in the subpopulation of pharmaceutical patents. This finding may suggest that (consistent with conventional wisdom) more examiner citations can in fact indicate a more thorough examination, but only in industries with relatively low patent density and/or relatively clear claims.

Fourth, we find that several variables that failed to yield significant results in the population of patents do have a significant correlation with institution among one or more subpopulations. We find that the count of a challenged patent's U.S. parent applications is a significant predictor of institution for pharmaceutical patents and NPE patents. Additionally (and quite interestingly), we find that the relationship runs in the opposite direction for these groups. Pharmaceutical patents with more parent applications are *less* likely to be instituted,

283. *See* Parker v. Flook, 437 U.S. 584, 590 (1978) (explaining that the law should prevent broad claims from issuing even if their breadth has been obscured by "[a] competent draftsman"); Mark A. Lemley, *Software Patents and the Return of Functional Claiming*, 2013 WIS. L. REV. 905, 907 (noting that "experienced patent lawyers today . . . increasingly [draft patent claims to cover] . . . the function of [their client's] program, not merely the particular way they achieved that goal"); Josh Feng & Xavier Jaravel, *Who Feeds the Trolls? Patent Trolls and the Patent Examination Process* 4 (Harvard Univ. & Stanford Univ., Working Paper, July 11, 2016), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2838017 [https://perma.cc/AQM2-9Y4R] ("We find that patents purchased by NPEs are, on average, granted by examiners who allow more incremental patents and patents with vaguer language.").

284. *See supra* notes 241–242 and accompanying text.

while NPE-owned patents with more parents are *more* likely to be instituted. The magnitude of the effect for pharmaceutical patents is also particularly striking, with one additional parent application associated with a nearly 9 percent decrease in the chance of institution. On one hand, a large number of parents may reflect applicants' desire to perfect the claims covering a valuable product, while on the other it may reflect applicants' struggle to patent a marginal innovation in a crowded technological space. Potentially, our results reflect that the former effect is more common in pharmaceutical patent prosecution, while the latter is more common among patents that eventually wind up in the hands of NPEs.[285]

Fifth, we find that the forward citation count for challenged patents, while not significant among the population of patents, has a significant negative relationship with institution for one subpopulation: patents owned by PAEs. On one hand, as discussed above, citations by subsequent patents may reveal the importance of the technology that a patent covers. On the other hand, Lerner has shown a "publicity effect" which tends to increase citations to patents that have previously been asserted,[286] which may suggest that higher quality PAE-owned patents are cited more often because they are litigated more often, not because they are more fundamental.

285. This hypothesis may also be supported by the fact that we find a negative coefficient for patents prosecuted by large law firms and a positive coefficient for software patents, though neither effect is statistically significant.

286. Josh Lerner, Trolls on State Street?: The Litigation of Financial Patents, 1976-2005 19–20 (2006) (unpublished manuscript), http://www.people.hbs.edu/jlerner/Trolls.pdf [https://perma.cc/63N9-J3Z8].

Table 20. Probit estimation of the likelihood a petitioned patent was never instituted (subset analysis)

	1 (Large)		2 (Medical)		3 (Pharma)		4 (Software)		5 (NPE)		6 (PAE)	
Applicant, Prosecutor and Examiner Characteristics:												
Allowance rate differential (rel. to Art Unit)	-0.315**	(0.124)	-0.386**	(0.171)	-0.279	(0.253)	-0.349**	(0.178)	-0.466***	(0.124)	-0.433***	(0.136)
Patent Characteristics:												
Quarter First Institution Decision	0.0100**	(0.0040)	0.0175**	(0.0069)	0.013	(0.011)	0.006	(0.005)	0.0009	(0.0034)	-0.004	(0.004)
Pendency (years)	0.014	(0.009)	0.020	(0.014)	0.017	(0.022)	-0.009	(0.011)	0.0021	(0.075)	0.0053	(0.085)
No. IPC Classes	-0.0036	(0.0037)					0.0094**	(0.0047)	0.0070**	(0.0034)	0.0050	(0.0039)
No. US Patent Classes			-0.021**	(0.010)	-0.000375							
Word Count / Claim	.000012*	(-0.000006)	0.000024**	(-0.00001)	0.000039**	(-0.000015)	0.000002	(-0.000019)	0.000016**	(-0.000007)	-0.000033	(-0.000021)
Unique Word Count of Claim 1	0.0011	(0.0008)	0.0030**	(0.0012)	0.0055**	(0.0026)	0.0022**	(0.0010)	-0.0005	(0.0008)	-0.0008	(0.0008)
Examination Intensity												
No. Backward Citations	-0.00024***	(0.00006)	-0.00027	(0.00018)	-0.0010***	(0.0004)	-0.00021***	(0.00008)	-0.00011**	(0.00005)	-0.00005	(0.00006)
No. Rev. Cites Added by Examiner	-0.0044**	(0.0022)	-0.0038	(0.0043)	0.026	(0.016)	0.0008	(0.0019)	-0.0006	(0.0018)	0.0014	(0.0019)
No. IDS Filed	0.0049	(0.0039)	-0.0032	(0.0072)	-0.003	(0.012)	0.0060	(0.0053)	0.0002	(0.0038)	-0.0001	(0.0039)
No. Final Rejections	0.013	(0.025)	0.003	(0.036)	0.014	(0.061)	0.019	(0.031)	0.016	(0.019)	-0.006	(0.022)
No. Parent Applications	0.004	(0.008)	-0.012	(0.014)	0.089***	(0.029)	-0.0083	(0.0068)	-0.016***	(0.005)	-0.010	(0.006)
Post-Grant Characteristics												
Forward citations	0.0001	(0.0002)	-0.0004	(0.0005)	0.0010	(0.0012)	0.00003	(0.00029)	0.00020	(0.00014)	0.00031**	(0.00014)
Log-likelihood	-526		-225		-106		-281		-420		-289	
Observations	874		373		181		504		829		621	

Note: analysis of six subsets of the population of 2,532 patents subject to an inter partes review institution decision on the merits between September 16, 2012, and January 31, 2017. Some patents were the subject of multiple merit institution decisions and accordingly, "Never Instituted" versus "Instituted" compares the 671 petitioned patents never instituted on the merits to the 1,861 patents instituted at least once. Marginal effects reported with discrete change of dummy variables from 0 to 1. Robust standard errors included in parenthesis. * p < .10; ** p < .05; and *** p < .01.

VI. IMPLICATIONS

Finally, we make a few broad observations in light of the data reported above. We then consider what patent reforms our observations suggest might help improve patent quality, and conclude with a caution that our results should be viewed with their limitations in mind.

A. Analysis

First and perhaps foremost, our findings suggest that patent quality is heavily influenced by the people and entities who are directly involved in the examination process. On the side of the applicant, we found that instituted patents are more likely to possess traits suggestive of a lack of sophistication and resources (e.g., small entity status, individual original assignees, and selection of "solo" prosecution counsel) and less likely to possess indicators of applicants' willingness and ability to pay for premium legal services (i.e., those provided by large law firms).

Also, with respect to the examiners assigned to challenged patents, we consistently found a significant, negative relationship between institution and both an examiner's overall allowance rate and the length of an examiner's tenure with the USPTO. Interestingly, these correlations survive controls for other examination-related variables including counts of rejections, IDSs, and backward citations, and thus suggest an effect that supersedes what is observable in individual prosecution histories.

We additionally find evidence that patent breadth is important to patent quality. Consistent with conventional wisdom, we find significant associations between institution and the number of U.S. technology classes assigned to a patent, the length of a patent's first claim, and the length of a patent's specification relative to its claim count.

Second, we find it noteworthy that many of the patent traits we examined had little or no correlation with institution. Despite their importance in the existing literature,[287] we found

287. *See supra* notes 27–34.

little evidence that forward citation counts are a strong predictor of quality. In the multivariate analyses reported in Tables 18 and 19, we also found little evidence that the age of petitioned patents or the technology to which they relate played a major role in IPR validity determinations. We likewise found little evidence linking validity to the prosecution of related applications in other countries. These latter three findings suggest that USPTO examination (while no doubt far from perfect) has been more consistent than many have believed over the last two decades, as well as more consistent with the quality of examination conducted overseas by foreign patent offices. Similarly, our findings suggest that the PTAB is not biased in favor of or against any particular type of technology.

That said, our findings do suggest that APJs may not be entirely insulated from outside influences. For example, our findings show that institution rates have fallen over time, even when controlling for numerous other variables. This may well be a reaction to the loud outcry from the patent bar about the high rates of invalidity seen in the first several months of the PTAB's existence, or instead a practical workload-reducing response to the PTAB's unexpectedly high caseload. We likewise see that patents owned by NPEs and PAEs are more likely to be instituted even when we control for all the other significant patent traits, a fact that plausibly reflects some degree of bias against the widely publicized litigation tactics of so-called "patent trolls."[288]

B. Recommendations

While we are reluctant to make strong causal claims based on our findings, our observations do tend to suggest a few promising avenues for improving the quality of patents issued by the USPTO. First, our findings are quite consistent with existing research indicating that U.S. patent examiners have suboptimal incentives to produce quality patents. Accordingly, our findings lend support to ongoing efforts to modify U.S. patent-examining procedures so that, for example, senior examiners are given additional time to review the applications they

288. Given that these potential influences may vary by judge, we recommend that future research in this area investigate variations in institution rates across APJs.

are assigned.[289] In addition, our findings suggest that the USPTO may wish to consider additional scrutiny of the prior art searches and office actions produced by examiners with relatively high grant rates as well as the training and oversight afforded to examiners in art units with relatively high grant rates. Indeed, the USPTO may wish to consider requiring that *all* decisions to grant applications, rather than only those made by relatively junior examiners,[290] be reviewed by a second examiner.[291]

Second, our findings suggest that relatively broad applications tend to issue as relatively low-quality patents. Accordingly, our findings suggest that the USPTO may wish to take steps to discourage, prevent, or provide additional scrutiny to especially lengthy or broad applications. For example, the USPTO could consider increasing existing "excess claim" and "size" fees,[292] or increasing the frequency with which examiners issue "restriction requirements" to break up complex applications into a series of smaller ones.[293] The USPTO may also wish to consider special examination procedures for applications that span numerous technology classes, perhaps by assigning multiple examiners with varied technical expertise to work as a team on such applications.

Third, our findings suggest that relatively small applicants are disproportionately likely to obtain low-quality patents. While this effect may have a number of explanations, its close relationship to the size of prosecution counsel tends to suggest that our findings reflect, at least to some extent, applicant sophistication and resources. Accordingly, our findings tend to support USPTO efforts to educate applicants that are relatively small and relatively new, including with respect to the importance of selecting competent counsel, the duty to disclose

289. *See* Michael D. Frakes & Melissa Wasserman, *Decreasing the Patent Office's Incentives to Grant Invalid Patents*, HAMILTON PROJECT (Dec. 2017), https://www.brookings.edu/wp-content/uploads/2017/12/es_121317_decreasing_patent_office_incentives_grant_invalid_patents_pb.pdf [https://perma.cc/656K-2KAA].

290. That is, those at pay grades GS-13 and below. *See supra* note 223.

291. *Accord* Feng & Jaravel, *supra* note 283, at 54 (estimating "that the share of NPE patents among granted patents could be reduced by 20% by implementing a 'second pair of eyes' policy").

292. USPTO, FEE SCHEDULE, https://www.uspto.gov/learning-and-resources/fees-and-payment/uspto-fee-schedule#Patent Fees (last accessed Jan. 14, 2018) [https://perma.cc/7YB7-DGTE].

293. *See* MPEP §§ 802–803 (9th ed. Rev. Aug. 2017).

prior art, careful claim drafting, and adequate technical disclosure in the specification.

Last, but not least, we believe that our findings tend to suggest that inter partes review is working as intended to eliminate low-quality patents. Despite years of criticism from many in the patent bench and bar, we find that the patents flagged as problematic by the PTAB largely bear the traditional hallmarks of low quality identified by conventional wisdom and prior academic research. At the same time, we find little evidence of bias for or against particular industries or types of patent owners (with the possible exception of PAEs). Accordingly, our findings do not tend to support ongoing efforts to radically restructure or outright eliminate inter partes review.

C. Limitations

An important caveat to the above recommendations, as well as to our findings generally, is that our data is limited in a number of respects. For one, as discussed in greater detail *supra* in Section III.B, the population of patents subjected to inter partes review is no doubt a highly selected sample of the total population of U.S. patents. While we believe that our population of patents is *less* selected than those used by many prior researchers, we nonetheless acknowledge that our findings likely reflect some degree of selection bias. As a result, our findings would likely change to at least some extent if a more diverse set of patents was challenged in inter partes review, as well as if fewer petitions settled prior to the issuance of an institution decision.[294]

In addition, inter partes review serves as a check on patent validity only with respect to anticipation and obviousness in light of printed prior art. While these are by far the most common bases on which U.S. patent applications have been rejected and issued patents have been invalidated,[295] our analysis excludes other grounds of invalidity, including limits on patentable subject matter, the substantial and specific utility requirements, enablement, written description, indefiniteness,

294. However, insofar as patents selected for IPR are only those worth spending five- or six-figures to challenge, policymakers may be less concerned about the multitude of lower-value patents missing from our study.

295. *See* Lu et al., *supra* note 82.

best mode, and the various other ways in which a patent may be invalidated under sections 102 and 103 of the Patent Act. Accordingly, our study of patent quality is, by definition, a somewhat incomplete one. As a result, our findings would likely change to at least some extent if it were possible to challenge patents on additional grounds in inter partes review proceedings.

Finally, we acknowledge the existence of two additional limitations inherent in using inter partes review institution decisions as a filter of patent quality. First, institution decisions are, to some extent, preliminary in nature and, thus, are prone to some degree of error. As discussed above, a nontrivial number of final written decisions confirm the patentability of all instituted claims. While we account for those decisions when they occurred, many inter partes reviews settled after institution but before a final written decision. In addition, though the affirmance rate is high for PTAB decisions, a nontrivial number of decisions are reversed on appeal. As a result, it is likely that a subsequent, more searching review of challenged claims would in some instances lead to a conclusion contrary to the one in this analysis. Second, while patent validity is determined on a claim-by-claim basis, our analysis focuses on the attributes of entire patents. Thus, as described in greater detail above, our analysis of institution decisions is incomplete because it lumps together all once-instituted (or always-instituted) patents despite the fact that many of these patents contain claims that were never challenged in the first place, as well as claims that were challenged but not instituted or not cancelled. In a future iteration of this project, we hope to take a claim-level view of validity in order to overcome this limitation.

CONCLUSION

Despite these limitations, we believe that this project is the most comprehensive look at patent quality undertaken to date. By taking advantage of the recent popularity of inter partes review, we were able to assemble a set of more than 2,500 U.S. patents that were the subject of at least one post-grant decision with respect to the validity of their claims. In addition, by taking advantage of the USPTO's recent releases of bulk data to the public, we were able to collect a large amount of data about each patent. Beyond information availa-

ble on the face of challenged patents, we were able to identify and assess each patent's examiner and prosecution counsel, as well as information about the various kinds of documents filed during each patent's prosecution.

Merging these two sets of data, we uncovered a number of patent attributes with a strong, significant relationship to institution, including characteristics of the people who prosecuted and examined challenged patents, characteristics of the challenged patents themselves, and characteristics of the prosecution history associated with each patent. Using the results of these bivariate comparisons, we selected a subset of characteristics for further analysis in a series of multivariate regressions.

Our multivariate analysis, in turn, revealed a number of especially significant predictors of institution. Notably, our findings largely complement earlier research on patent quality. Consistent with Frakes and Wasserman, we find that more senior examiners (and those who aspire to promotion) may face incentives that are detrimental to patent quality on the margin. Similarly, consistent with Lei and Wright, we find a counterintuitive, negative relationship between backward citations and quality. At the same time, our findings reveal a number of unexpected wrinkles that we believe warrant further research. We find, for example, that software and business methods patents perform surprisingly well in IPR. We also fail to find significance among several variables that have been used as quality proxies in prior research, including forward citation counts and concurrent examination by the EPO.

In addition to refining our ability to identify high- and low-quality patents, our findings have importance for ongoing debates about how to improve ex ante patent examination and how to measure the efficacy of inter partes review. While it is impossible for us to conclude that any change in patent examination policy or procedure would be cost justified,[296] our results suggest several actions that patent offices in the United States and abroad may wish to investigate to improve patent quality, including additional oversight of examiners with high allowance rates and greater scrutiny of especially complex applica-

296. Meaning that the benefit to society from increases in patent quality would exceed the costs of making the changes necessary to achieve those increases.

tions. Further, our results suggest that to the extent that the PTAB is acting as a "patent death squad," it is a death squad targeting patents with indicia of relatively low quality, rather than indicia of relatively high value. For example, medical and pharma patents, which scholars tend to believe possess clearer boundaries and higher per-patent value, have much lower institution rates than other patents, while NPE and PAE patents, which are often used primarily for nuisance value assertion, are more likely to be instituted. As the PTAB continues to reassess the validity of hundreds of additional patents each year, we urge policymakers, PTO administrators, and scholars to follow our lead in mining that data in search of new avenues to improve patent office accuracy, efficiency, and fairness.

APPENDIX

Table A.1. Probit estimation of the likelihood a petitioned patent was denied institution (subset analysis)

	1 (Large)		2 (Medical)		3 (Pharma)		4 (Software)		5 (NPE)		6 (PAE)	
Applicant, prosecutor and examiner characteristics:												
Allowance rate differential (rel. to Art Unit)	-0.299**	(0.128)	-0.335**	(0.175)	-0.210	(0.254)	-0.179	(0.197)	-0.225	(0.144)	-0.139	(0.177)
Patent characteristics:												
Pendency (years)	-0.0011	(0.0093)	0.013	(0.014)	-0.003	(0.023)	-0.020*	(0.012)	-0.0058	(0.086)	0.0050	(0.085)
No. IPC classes	-0.0025	(0.0038)					0.012**	(0.005)	0.0068*	(0.0039)	0.0051	(0.0039)
No. U.S. patent classes			-0.018*	(0.010)	-0.020	(0.013)						
Word count / claim	0.000005	(0.000007)	0.000021**	(0.00001)	0.000036**	(0.000017)	-0.000006	(0.00002)	0.000012	(0.000008)	-0.000032**	(0.000021)
Unique word count of claim 1	0.0016**	(0.0008)	0.0029**	(0.0012)	0.0044**	(0.0022)	0.002*	(0.0011)	0.0008	(0.0009)	0.001	(0.001)
Examination intensity												
No. backward citations	-0.00008	(0.00006)	-0.00015	(0.00016)	-0.0007*	(0.0004)	-0.00009	(0.00008)	-0.00006	(0.00006)	0.00002	(0.00007)
No. rev. cites added by examiner	0.0054***	(0.002)	-0.0049	(0.0045)	0.032**	(0.016)	-0.001	(0.002)	-0.0009	(0.002)	-0.002	(0.0022)
No. IDS filed	0.0038	(0.0042)	-0.0017	(0.0074)	-0.007	(0.011)	0.0028	(0.0056)	0.0032	(0.0035)	0.0027	(0.0037)
No. final rejections	0.042	(0.027)	0.009	(0.036)	0.065	(0.063)	0.049	(0.034)	0.028	(0.022)	-0.007	(0.026)
No. parent applications	-0.001	(0.008)	-0.008	(0.014)	0.076**	(0.029)	-0.014*	(0.007)	-0.016***	(0.006)	-0.015**	(0.007)
Post-grant characteristics												
Forward citations	0.0001	(0.0003)	-0.0006	(0.0005)	0.0022	(0.0014)	-0.0003	(0.0003)	0.00015	(0.00017)	0.00023	(0.00018)
Log-likelihood	-571		-242		-113		-317		-504		-366	
Observations	874		373		181		504		829		621	

Note: analysis of six subsets of the population of 2,532 patents subject to an inter partes review institution decision on the merits between September 16, 2012, and January 31, 2017. Some patents were the subject of multiple merit institution decisions and accordingly, “Never Instituted” versus “Instituted” compares the 671 petitioned patents never instituted on the merits to the 1,861 patents instituted at least once. Marginal effects reported with discrete change of dummy variables from 0 to 1. Robust standard errors included in parenthesis. * p < .10; ** p < .05; and *** p < .01.