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A New Approach to Patent Reform

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Scholars and policymakers have tried for years to solve the tenacious and harmful crisis of low-quality, erroneously granted patents. Far from resolving the problem, these determined efforts have resulted in hundreds of conflicting policy proposals, failed congressional bills, and no way to evaluate the policies' value or impact or to decide between the overwhelming multiplicity of policies.

This Article provides not only new solutions but a new approach for designing and assessing policies both in patent law and legal systems more generally. We introduce a formal economic model of the patent system that differs from existing scholarship because it permits us to (1) determine how a policy change to one part of the patent system affects the system as a whole and (2) quantify the impact of policy changes. Existing scholarship typically analyzes a policy by assessing its effect on just the targeted element of the patent system, but legal systems are complex with interrelated components, and players react along multiple margins, so these analyses are incomplete and sometimes incorrect. Our approach fixes this problem, providing a comprehensive understanding of how a policy change affects the patent system from beginning to end. It also permits us to conduct complex analyses such as varying multiple policies at once. Further, much existing scholarship fails to quantify the magnitude of a policy's effect, and even empirical scholarship can only measure the effect of an already-implemented policy, not predict the effect of a proposed change. Quantification is critical because policies generally have multiple effects, often in countervailing directions. Quantification—as shown using our model—permits scholars to determine the overall direction and size of a theoretically ambiguous effect. Quantification also allows us to compare the social welfare effects of different reforms so that policymakers know where to focus their efforts.

We apply our model to several of the most prominent policy debates in patent law. We conclude that certain reforms, such as regulation of settlement licenses and increased examination intensity, yield large gains in social welfare and should be prioritized. Other reforms that are popular with scholars, including decreasing the availability of injunctions and reducing litigation costs, produce surprisingly small gains in social welfare. Often, existing

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scholarship operates too much on intuition which, we show, can be wrong. Our new approach to patent reform provides an approach that offers deeper understanding and a more effective evaluation framework.

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INTRODUCTION

Patents are supposed to cover new and innovative inventions, so why are there patents on old or obvious creations, such as a stick,¹ a method of swinging on a swing,² and bread with the crust cut off?³ The Patent Office regularly grants patents on inventions that should not have been patented with detrimental and widespread consequences for social welfare.⁴ This problem has been well-recognized and debated for decades.⁵ It has spawned an extensive scholarly literature and dozens of

1. U.S. Patent No. 6,360,693 col. 4 ll. 55–65 (issued Mar. 26, 2002).
2. U.S. Patent No. 6,368,227 col. 3 ll. 8–18 (issued Apr. 9, 2002).
3. U.S. Patent No. 6,004,596 col. 4 ll. 14–32 (issued Dec. 21, 1999).
4. *E.g.*, JAMES BESSEN & MICHAEL J. MEURER, PATENT FAILURE: HOW JUDGES, BUREAUCRATS, AND LAWYERS PUT INNOVATORS AT RISK 8-9 (2008).
5. *See infra* Part I.

congressional bills proposing policies to improve patent quality.⁶ The content of these proposed policies varies significantly—from strategies to make patent applications more expensive to file⁷ to increasing the intensity of examination at the Patent Office,⁸ changing substantive legal doctrines of patentability,⁹ reducing patent term,¹⁰ increasing the cost of maintaining granted patents,¹¹ easing the process of reviewing patentability after a patent has been granted,¹² and altering procedural and remedial aspects of litigation.¹³ Even with creative thinking on this topic, scores of wide-ranging policy proposals, and appetite for political reform, patent quality remains a problem and there is no consensus on the best solution(s).¹⁴

Despite its insights, patent law scholarship may be partially at fault for this morass of failed reform efforts. Reform advocates systematically make several crucial errors that render existing policy predictions unreliable, misleading, or outright wrong.¹⁵ First, overly simplistic analyses of policies focus on the impact of reform on just one part of the patent system—but reforms generally have consequences for multiple parts of the system, and affected parties will react along multiple margins, not merely in the specific area of change.¹⁶ To illustrate, imagine a policy proposal to improve litigation procedures that accurately predicts that the policy will ameliorate litigation outcomes but fails to consider detrimental changes to a second area of the patent system—for instance, decisions to file patents. If the unaccounted-for negative effects outweigh the positive, the proposal will be counterproductive. A second critical error in existing scholarship is that it does not seek to *quantify* the magnitude of a policy's impact.¹⁷ Reforms generally have multiple effects with both positive and negative effects on social welfare—without

6. See *infra* note 4.

7. E.g., Jonathan S. Masur, *Costly Screens and Patent Examination*, 2 J. LEGAL ANALYSIS 687, 690 (2010).

8. E.g., Daniel E. Ho & Lisa Larrimore Ouellette, *Improving Scientific Judgments in Law and Government: A Field Experiment of Patent Peer Review*, 17 J. EMPIRICAL LEGAL STUD. 190, 190 (2020).

9. E.g., Peter S. Menell, *A Method for Reforming the Patent System*, 13 MICH. TELECOMM. & TECH. L. REV. 487, 498 (2007).

10. E.g., Brian J. Love, *An Empirical Study of Patent Litigation Timing: Could A Patent Term Reduction Decimate Trolls Without Harming Innovators?*, 161 U. PA. L. REV. 1309, 1309 (2013).

11. E.g., David S. Olson, *Removing the Troll from the Thicket: The Case for Enhancing Patent Maintenance Fees in Relation to the Size of a Patent Owner's Patent Portfolio*, 68 FLA. L. REV. 519, 544 (2016).

12. E.g., 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, 964-68 (2004).

13. E.g., F. Scott Kieff, *The Case for Preferring Patent-Validity Litigation over Second-Window Review and Gold-Plated Patents: When One Size Doesn't Fit All, How Could Two Do the Trick?*, 157 U. PA. L. REV. 1937, 1953-54 (2009).

14. See *infra* Part I.

15. See *infra* Section I.C.

16. See *infra* Section I.C.

17. See *infra* Section I.C.

quantification, policymakers cannot know whether overall the reform will be helpful or harmful.¹⁸

We introduce a new approach to patent reform that constructively addresses both of the above problems and, when applied to some of the thorniest problems in patent law, provides new, concrete recommendations for patent policy. Our approach to policy design and evaluation uses a formal economic model of innovation, patenting, licensing, and litigation that is calibrated to mimic the real-world behavior of the American innovation and patent system.¹⁹ The model uses an integrated equilibrium framework to make theoretical predictions and then quantify the magnitude of the policy effects.²⁰ These three key features—equilibrium, integration, and quantification—permit us to provide a methodology for policy analysis that has not been previously used in the legal literature²¹ and give improved recommendations about some of the most important policy questions in patent law²² and help us reframe the debate about whether intervention to improve quality should occur before or after a patent is granted.²³

To elaborate on the features of our model, the equilibrium allows us to trace direct and indirect adjustments that affected parties make in response to a policy change. The economic concept of equilibrium assures that one party optimally adjusts its behavior in response to changes in the environment and to the adjustments made by other parties in all relevant parts of the system.²⁴ We describe our model as integrated to emphasize that the model includes multiple aspects of the innovation and patent system; it can predict changes both to the targeted aspect of the system as well as how those changes reverberate throughout the system.²⁵ Quantification permits measurement and comparison of the magnitudes of these effects. Moreover, our calibrated model allows us to explore the effects of proposed reform, while the leading empirical alternative is limited to reforms that were implemented long enough in the past to generate “before and after” data.²⁶

As an example of the value of an integrated, equilibrium framework with quantification, we assess the impact of the Supreme Court’s *Federal Trade Commission v. Actavis* decision, which regulates the terms of patent litigation settlement agreements, thereby making it more difficult for litigants to agree to halt or circumvent court proceedings.²⁷ The *Actavis* reforms are a popular topic of scholarly analysis, much of which focuses on the first-order conclusion that when

18. For examples of policies with effects throughout the patent system, see *infra* Section I.B.

19. See *infra* Part II.

20. See *infra* Part II.

21. See *infra* Part II.

22. See *infra* Sections III.A–B.

23. See *infra* Section III.C.

24. LAWRENCE A. BOLAND, EQUILIBRIUM MODELS IN ECONOMICS: PURPOSES AND CRITICAL LIMITATIONS 13 (2017).

25. We elaborate further in *infra* Section II.A.

26. See *infra* Section II.C.

27. Fed. Trade Comm’n v. Actavis, Inc., 570 U.S. 136, 141 (2013).

parties have unrestricted ability to settle, owners of low-quality patents can settle to stop litigation, which ends the case and prevents courts from reaching a decision that would invalidate patents. Consequently, patent quality would improve if settlements by the owners of low-quality patents decline and courts invalidate more of these patents.²⁸ This analysis is clearly important, but it is only a beginning—we must trace other equilibrium responses at different stages of the patent system.²⁹ Using our model, several other responses of interest to policymakers become clear. In particular, the cost of patent enforcement via litigation increases, which may decrease incentives to invent.³⁰

When these direct and indirect effects of settlement restraints are considered, the direction of the policy's effect on patent quality becomes ambiguous. In some respects—such as the ability of courts to invalidate bad patents, for instance—restraints on settlement should improve patent quality. In other respects—such as decreased incentives to invent—restraints on settlement might reduce patent quality by disproportionately deterring high-quality inventions. These countervailing effects reveal the importance of quantification.³¹ Our calibrated model can be used to estimate the magnitude of the policy's effects.³² As we show, despite the presence of both positive and negative effects of restraints on settlement on quality and social welfare, the ultimate effect of the policy is large and positive: a 3.6% gain in welfare.³³

The generalizable point—and a key contribution of our Article—is that the patent system (indeed any legal system) is complex, and good policy analysis should recognize that affected parties will adjust their behavior, potentially in disparate parts of the system. Thus, effective analysis requires an understanding of reform consequences across the patent system coupled with quantification of the direct and indirect effects of reform.

We emphasize the utility of our approach and how it differs from existing scholarly conclusions with analyses of many other central questions in patent policy. Take, for example, the Supreme Court's decision in *eBay v. MercExchange*, which reduced the availability of injunctions in patent cases, favoring damages instead.³⁴

28. This analysis is common in existing scholarship and policy work. *E.g.*, Brief for 118 Law, Economics, and Business Professors and the American Antitrust Institute as Amici Curiae Supporting Petitioners at 17, *Fed. Trade Comm'n v. Actavis, Inc.*, 570 U.S. 136 (2013); *see also* Daniel A. Crane, *Ease Over Accuracy in Assessing Patent Settlements*, 88 MINN. L. REV. 698, 700 (2004); Herbert Hovenkamp, Mark Janis & Mark A. Lemley, *Anticompetitive Settlement of Intellectual Property Disputes*, 87 MINN. L. REV. 1719, 1720 (2003); Carl Shapiro, *Antitrust Limits to Patent Settlements*, 34 RAND J. ECON. 391, 395 (2003).

29. We do so in more detail in *infra* Section III.A.1.

30. *See infra* Section III.A.1.

31. Note that quantification is also important when theoretical predictions are unidirectional because it allows comparison of the effects of different policy interventions and is crucial as policy makers make cost-benefit determinations.

32. *See infra* Section II.C.

33. *See infra* Section III.A.1.

34. *eBay Inc. v. MercExchange, L.L.C.*, 547 U.S. 388 (2006).

Injunctions are thought to give the patent owner a very strong bargaining position because if competitors do not pay, the patent owner can force the competitor to remove their product from the market entirely.³⁵ Disfavoring injunctions, therefore, should weaken the patent owner's position even if the patentee wins in litigation.³⁶ *eBay* is one of the most cited patent cases of the modern era because scholars predicted that it would have a large impact on litigation.³⁷ Our model finds—surprisingly, given the importance of *eBay* in patent scholarship—that *eBay* had a relatively muted impact: only a 0.1-0.2% increase in social welfare, far smaller than the 3.6% increase from the Court's policy intervention in *Actavis*, even though the latter has attracted considerably less scholarly attention.³⁸ We conclude that scholars rely too much on intuition to understand the effect of policy changes; intuition should be tempered by formal modeling with quantification of the impact of policy changes.

We also critically review one of the most active topics in patent scholarship: examination intensity (the amount of time, effort, and resources patent examiners put into reviewing patents).³⁹ Many scholars advocate increased examination intensity to improve patent quality,⁴⁰ while others favor maintaining a low level of examination intensity—or even eliminating examination entirely—and relying on litigation to weed out low-quality patents.⁴¹ In applying our model to this debate, we find that increased examination intensity has the potential to significantly improve social welfare (by 3.0%), whereas eliminating examination causes a large decrease (-5.3%).⁴² Our model also illuminates how the best choice of examination intensity depends on the design of other parts of the patent system including litigation and settlement.⁴³

Our approach is also useful for other key questions such as the appropriate balance between cost and accuracy in patent litigation (with implications for litigation in general).⁴⁴ Exploring this trade-off in our model does not yield clear theoretical guidance about which approach is best.⁴⁵ Adding quantification, however, suggests that reduced cost and accuracy may be socially desirable, but

35. Mark A. Lemley & Carl Shapiro, *Patent Holdup and Royalty Stacking*, 85 TEX. L. REV. 1991, 2035 (2007).

36. *Id.*

37. Dennis Crouch, *Most Cited Supreme Court Patent Cases Since 1952*, PATENTLY-O (Dec. 20, 2021), <https://patentlyo.com/patent/2021/12/cited-supreme-patent.html> [perma.cc/RRH3-VY4M].

38. *See infra* Section III.A.2.

39. For a summary of aspects of this debate, see, for example, Michael D. Frakes & Melissa F. Wasserman, *Irrational Ignorance at the Patent Office*, 72 VAND. L. REV. 975, 982 (2019).

40. *Id.*; see also Arti K. Rai, *Engaging Facts and Policy: A Multi-Institutional Approach to Patent System Reform*, 103 COLUM. L. REV. 1035, 1081 (2003). Other suggested reforms are discussed in *infra* Part I.

41. *E.g.*, F. Scott Kieff, *The Case for Registering Patents and the Law and Economics of Present Patent-Obtaining Rules*, 45 B.C. L. REV. 55, 70 (2003).

42. *See infra* Section III.B.1.

43. *See infra* Section III.B.1.

44. *See infra* Section III.A.3; see also Louis Kaplow, *Rules Versus Standards: An Economic Analysis*, 42 DUKE L.J. 557, 557 (1992).

45. *See infra* Section III.A.3.

surprisingly, even large changes in cost and accuracy have relatively little impact on overall social welfare.⁴⁶ This highlights the importance of quantification because a sound theoretical argument for or against reform can be countered by showing the magnitude of its social welfare effect is likely to be small.

In addition to insights into specific policy reforms, we also offer a significant reformulation to how scholars approach the theory of patent reform. Much patent scholarship is bifurcated into those favoring “early” reforms—fixes at the Patent Office to screen out low-quality applications—and those favoring “late” reforms—changes to litigation so that courts could invalidate more low-quality patents.⁴⁷ Our method of assessing patent reform gives us theoretical and empirical reasons to reject this polarized “before-or-after” approach. First, we show that reforms implemented after patent grant can influence behavior before patent grant; “after” reforms, therefore, are *also* “before” reforms and vice versa.⁴⁸ Second, our model allows us to predict the effect of varying multiple policies at once; doing so shows that “before” and “after” policies can be complementary.⁴⁹ Finally, our quantified model indicates that increased examination intensity, a pre-grant reform, and regulation of settlement licenses, a post-grant reform, both promise to increase social welfare significantly, while other pre- and post-grant reforms offer little or no gain in terms of social welfare.⁵⁰ It is not, therefore, that reforms before grant are categorically better (or worse) than reforms after grant but rather that both types of reform can be helpful, unproductive, or worse, counterproductive.

Of course, caveats are in order. We propose one specific model and make certain choices about what to include and exclude in the model, as we do with the calibration exercise. Although we validate the model and believe it is a reasonable (if stylized) presentation of the patent system, it is not the only way the exercise could be conducted. The broader conclusion of this Article lies, therefore, not only in the specific policy conclusions but in the general method; accounting for the complex and multifaceted nature of the patent system and of legal systems in general allows a system-wide view of the effect of multiple policy instruments on patent quality and social welfare.

The Article proceeds as follows. Part I provides background on the patent system, including the problems with low-quality patents and existing literature on reforms to improve patent quality. Part II outlines a theoretical model of the patent system and explains how we quantify the social welfare effects of patent reforms. Part III uses the model to perform integrated analyses of patent policy: Part III.A addresses post-grant reforms, Part III.B addresses pre-grant reforms, and Part III.C discusses interaction between reforms. Part IV turns to caveats about the model and possible variations and extensions on the work, lessons for policymakers,

46. See *infra* Section III.A.3.

47. Mark A. Lemley, *Rational Ignorance at the Patent Office*, 95 NW. U.L. REV. 1495, 1495–97 (2001).

48. See *infra* Part III.

49. See *infra* Part III.

50. See *infra* Part III.

and how this project can inform policy not just in patent law but throughout the legal system.

I. BACKGROUND

To contextualize our discussion of responses to low patent quality, we begin with an explanation of why low-quality patents may be an impediment to the goals of the patent system (Part I.A). We additionally explore ways in which patent policy and design of the patent system can affect the quantity and nature of low-quality patents. We then turn to existing proposals for reform—from both scholarship and legislation—and sample some of that extensive literature to highlight the sheer number and scope of these proposals (Part I.B). We first summarize these proposals but do not discuss their strengths and weaknesses. We then revisit a selection of these proposals in Part I.C to address them more critically.

A. *A Primer on Patent Quality*

Most commentators agree that the Patent Office issues many low-quality patents.⁵¹ Low-quality patents have inspired copious scholarship because they have the potential to thwart the key goal of the patent system—incentivizing innovation⁵²—and impose unnecessary social costs.⁵³ For the same reasons, there have been several dozen bills introduced in Congress in recent years (few of which have passed) all seeking to reform the patent system to reduce the number or impact of low-quality patents.⁵⁴ Here, we define low-quality patents and explain why they might counteract innovation incentives and create additional social costs.

51. See, e.g., R. Polk Wagner, *Understanding Patent-Quality Mechanisms*, 157 U. PA. L. REV. 2135, 2136 (2009).

52. U.S. CONST. art. I, § 8 (giving Congress the power to issue patents to “promote the progress of science and useful arts”).

53. See generally Wagner, *supra* note 51.

54. A sampling of recent bills to improve patent quality is below. Broadly speaking, these bills target low-quality patents by making them more difficult to assert in litigation (either increasing the cost of litigation or heightening procedural requirements to make litigation more difficult and thus less worthwhile for litigants unlikely to prevail) or by increasing United States Patent and Trademark Office (“USPTO”) funding to improve examination. Note that some provisions would affect both high- and low-quality patents. Innovation Act, H.R. 3309, 113th Cong. (2013) (allowing the addition of any real party in interest to litigation, providing provisions for fee shifting in litigation, and delaying discovery until after claim construction); Patent Transparency and Improvements Act, S. 1720, 113th Cong. (2013) (providing protections for end users, granting the F.T.C. powers to act on demand letters); Patent Quality Improvement Act, S. 866, 113th Cong. (2013) (expanding the Covered Business Method review program to other industries and preventing the program from expiring); Patent Abuse Reduction Act, S. 1013, 113th Cong. (2013) (heightening pleading requirements, allowing the addition of any real party in interest to litigation, reducing discovery costs, providing provisions for fee shifting in litigation); Patent Litigation Integrity Act, S. 1612, 113th Cong. (2013) (providing provisions for fee shifting in litigation); Transparency in Assertion of Patents Act, S. 2049, 113th Cong. (2014) (requiring notice of patent infringement); Patent Fee Integrity Act, S. 2146, 113th Cong. (2014) (increasing funding to the USPTO by allowing it to keep all collected fees); Trade Protection Not Troll Protection Act, H.R. 4763, 113th Cong. (2014) (modifying procedures at the ITC to decrease its use by patent assertion entities); Demand Letter Transparency Act, H.R. 3540, 113th Cong. (2014) (creating publicity

We use the term “low-quality patent” in this article to mean patents granted on inventions that would have been developed even in the absence of a patent.⁵⁵ Patents incentivize innovation by giving inventors broad rights to exclude others from practicing their invention for the duration of the patent. This allows inventors to recoup research costs and profit on their inventions, either by working the patent themselves or licensing, underpinning the market for technology. However, this benefit to inventors comes at a cost: the public must pay higher prices for patented technologies during the term of the patent. Thus, patents should be limited to those inventions that would not have been developed in the absence of the patent incentive; to do otherwise imposes a social cost that was unnecessary to incentivize development of the invention.⁵⁶

requirements for demand letters and requiring certain disclosures in demand letters); Innovation Protection Act, H.R. 3349, 113th Cong. (2014) (increasing funding of USPTO); Patent Litigation and Innovation Act, H.R. 2639, 113th Cong. (2014) (increasing likelihood of sanctions for frivolous patent suits, amending procedural aspects of patent cases to reduce lawsuits by patent assertion entities); SHIELD Act, H.R. 845, 113th Cong. (2014) (requiring certain entities to post bond before litigation); Stopping the Offensive Use of Patents Act, H.R. 2766, 113th Cong. (2014) (expanding Covered Business Method review to all industries and making the program permanent); End Anonymous Patents Act, H.R. 2024, 113th Cong. (2014) (requiring transparency of patent owners); Protecting American Talent and Entrepreneurship Act, S. 1137, 114th Cong. (2015) (heightening pleading requirements in patent cases, reducing discovery costs, providing for fee shifting); Innovation Act, H.R. 9, 114th Cong. (2015) (heightening pleading requirements in patent cases, reducing discovery costs, providing for fee shifting); Venue Equity and Non-Uniformity Elimination Act, S. 2733, 114th Cong. (2016) (reforming venue rules to move cases out of the Eastern District of Texas, a patent-friendly forum); Trade Protection Not Troll Protection Act, H.R. 4829, 114th Cong. (2016) (altering procedural requirements at the International Trade Commission); Targeting Rogue and Opaque Letters Act, H.R. 2045, 114th Cong. (2015) (penalizing bad-faith demand letters); Demand Letter Transparency Act, H.R. 1896, 114th Cong. (2015) (creating publicity requirements for demand letters and requiring certain disclosures in demand letters); Innovation Protection Act, H.R. 3349 (2015) (increasing funding to the USPTO by allowing it to keep all collected fees); Study of Underrepresented Classes Chasing Engineering and Science Success Act, H.R. 6758, 115th Cong. (2017) (increasing funding to the USPTO); Trade Protection Not Troll Protection Act, H.R. 2189 (2017) (altering procedural requirements at the International Trade Commission).

55. Patent quality is defined in somewhat different terms in different contexts. For instance, some articles define low-quality patents as those that do not meet requirements of patentability and others use economic measures such as private value of the patent. *See, e.g.*, John R. Allison, Mark A. Lemley & Joshua Walker, *Patent Quality and Settlement Among Repeat Patent Litigants*, 99 GEO. L.J. 677, 677 (2010); Wagner, *supra* note 51, at 2138. Measuring patent quality is complex. *See, e.g.*, Jean O. Lanjouw & Mark Schankerman, *Patent Quality and Research Productivity: Measuring Innovation with Multiple Indicators*, 114 ECON. J. 495, 495 (2004).

56. This definition of quality is often used by courts and patent scholars, and the nonobviousness requirement is an attempt to proxy for this sort of quality, as it is hard to directly observe whether or not an invention is patent-induced. *See, e.g.*, *Graham v. John Deere Co.*, 383 U.S. 1, 11 (1966) (explaining that the purpose of the obviousness requirement is to “weed[] out those inventions which would not be disclosed or devised but for the inducement of a patent”); *see* Michael Abramowicz & John F. Duffy, *The Inducement Standard of Patentability*, 120 YALE L.J. 1590, 1593 (2011); Michael J. Meurer & Katherine J. Strandburg, *Patent Carrots and Sticks: A Model of Nonobviousness*, 12 LEWIS & CLARK L. REV. 547, 547 (2008). Notice that our notion of quality focuses on the question of whether a patent is needed to induce investment in development of invention rather than disclosure. We comment on disclosure in *infra* Section IV.A.

Low-quality patents abound. One notorious example is a patent claiming the invention of a stick.⁵⁷ This patent was clearly not necessary to incentivize the invention of sticks because humanity’s knowledge of sticks long predated the patent. Another well-known low-quality patent is Amazon’s patent on “one-click” ordering.⁵⁸ The patent claims a “method for placing an order for an item . . . in response to only a single action being performed.”⁵⁹ Critics (and the European Patent Office⁶⁰) note that the idea of one-click ordering existed before Amazon filed its patent and that the invention was a simple and obvious improvement on existing technology—the patent incentive was unnecessary to induce development of this technology.⁶¹

Grant of low-quality patents is not merely an administrative error; it can lead to significant costs. One such cost is higher prices for consumers. For instance, one driver of high drug prices is a patent-aided monopoly on many drugs that prevents entry of generic competition.⁶² If some patents on drugs are low-quality—as critics allege—then the additional patent-driven cost to consumers may be unnecessary in the sense that it was not required to incentivize the drug’s invention.⁶³

Low-quality patents may also indirectly increase costs to consumers without a commensurate social benefit if they are used to opportunistically extract licensing

57. U.S. Patent No. 6,360,693 (issued Mar. 26, 2002). The patent claims “an animal toy, comprising” a main section with “at least one protrusion . . . that is not in parallel alignment . . . wherein said animal toy is adapted to float on the water.” *Id.* at col. 4 ll. 55–65. This claim describes most tree branches (and a host of other objects invented or discovered long before the patent was filed). In an unusual move, the Director of the Patent Office ordered the patent reexamined, and the Patent Office cancelled the patent’s claims—recognition that the patent was clearly invalid (and low-quality). Gene Quinn, *The Strange Case of the Animal Toy Patent: Reexam Redux*, IPWATCHDOG (Dec. 3, 2010, 11:19 AM), <https://ipwatchdog.com/2010/12/03/the-strange-case-of-the-animal-toy-patent-reexam-redux/id=13648/> [<https://perma.cc/68HY-KRPN>]. Note that this example is extreme because it is so clearly nonnovel. It could therefore realistically not be asserted in litigation because there is no credible argument for validity (beyond having a granted patent), unlike many other invalid patents where the case for invalidity is less clear.

58. U.S. Patent No. 5,960,411 (issued Sept. 28, 1999).

59. *Id.* at col. 10 ll. 15–19.

60. While the patent application was rejected at the European Patent Office, the U.S. Patent Office granted the patent and confirmed its validity in re-examination. Tim Worstall, *Amazon Loses 1-Click Patent*, FORBES (July 7, 2011, 10:18 AM), <https://www.forbes.com/sites/timworstall/2011/07/07/amazon-loses-1-click-patent/?sh=18b24fe21962> [<https://perma.cc/23EJ-98NA>]. The Federal Circuit, however, noted “substantial questions” about the validity of the patent and vacated the lower court’s grant of a preliminary injunction. *Amazon.com, Inc. v. Barnesandnoble.com, Inc.*, 239 F.3d 1343, 1366 (Fed. Cir. 2001).

61. See Margo A. Bagley, *Internet Business Model Patents: Obvious By Analogy*, 7 MICH. TELECOMM. TECH. L. REV. 253, 254–57 (2001). Patent law requires that an invention be “nonobvious” in order to be eligible for a patent. 35 U.S.C. § 103. This requirement is described as a “means of weeding out those inventions which would not be disclosed or devised but for the indcement of a patent.” *Graham*, 383 U.S. at 11; see also Abramowicz & Duffy, *supra* note 56, at 1590.

62. Rachel E. Sachs, *The Uneasy Case for Patent Law*, 117 MICH. L. REV. 499, 506–07 (2018).

63. C. Scott Hemphill & Bhaven N. Sampat, *Evergreening, Patent Challenges, and Effective Market Life in Pharmaceuticals*, 31 J. HEALTH ECON. 327, 327 (2012) (discuss generic challenges to low-quality pharmaceutical patents).

fees from innovative firms.⁶⁴ These opportunistic licensors do not themselves produce any innovation.⁶⁵ Patent assertion entities (or, pejoratively, “patent trolls”) then target other firms, those that do produce innovative goods, and seek licensing fees under threat of patent litigation.⁶⁶ If firms producing innovative goods are forced to either pay licensing fees or incur litigation costs to fight the PAE’s patent assertion, those payments are likely incorporated into the ultimate price of consumer goods. Because patents often have vague boundaries and unclear ownership, it is difficult—perhaps impossible—for firms to simply avoid infringing on PAE-owned patents.⁶⁷

Further, low-quality patents can impede innovation by deterring future work in a field.⁶⁸ If a researcher would like to develop next-generation widgets but realizes that there are many patents in the field, he or she may decide that the transaction costs involved in licensing each patent are prohibitive and may abandon the project.⁶⁹

B. Policy Levers for Patent Quality

This Section surveys the voluminous literature proposing policy reform and gives examples of how policy can be used in multiple domains of the patent system to impact patent quality. This Section also illustrates the abundance of policy options, the general lack of consensus among scholars and policymakers about the best way to approach the problem of patent quality, and failure to quantitatively

64. James Bessen, Jennifer Ford & Michael J. Meurer, *The Private and Social Costs of Patent Trolls*, 34 REG. 26, 26 (2012).

65. *Id.* Payments from licensors also help inventors monetize their innovation, providing an incentive for that innovation. *E.g.*, Christopher A. Cotropia, Jay P. Kesan & David L. Schwartz, *Unpacking Patent Assertion Entities*, 99 MINN. L. REV. 649, 653 (2014), Janet Freilich, *Patent Shopping*, 10 U.C. IRVINE L. REV. 619, 629 (2020). Small firms may not otherwise be able to enforce patents. Jean O. Lanjouw & Mark Schankerman, *Protecting Intellectual Property Rights: Are Small Firms Handicapped?*, 47 J.L. & ECON. 46, 46 (2004).

66. Bessen, Ford & Meurer, *supra* note 64, at 26.

67. BESSEN & MEURER, *supra* note 4, at 8.

68. Michael A. Heller & Rebecca S. Eisenberg, *Can Patents Deter Innovation? The Anticommons in Biomedical Research*, 280 SCI. 698, 698 (1998). *But see* Jonathan M. Barnett, *The Anti-Commons Revisited*, 29 HARV. J.L. & TECH. 127, 141 (2015) (arguing that the market is able to solve the anticommons problem). A related concern is fragmentation of patent rights, which may increase transaction costs. ADAM JAFFE & JOSH LERNER, *INNOVATION AND ITS DISCONTENTS*, 11 (2004). *But see* Alberto Galasso & Mark Schankerman, *Patent Thickets, Courts, and the Market for Innovation*, 41 RAND J. ECON. 472, 473 (2010) (modelling litigation settlements and finding that fragmented patent rights may increase the speed of settlement).

69. Empirical evidence of whether patents deter follow-on innovation is mixed. *Compare* Alberto Galasso & Mark Schankerman, *Patents and Cumulative Innovation: Causal Evidence from the Courts*, 130 Q. J. ECON. 317, 317 (2015) (finding that invalidation of a patent leads to a fifty percent increase in citations by later patents in some fields but no effect in non-complex technology fields), *with* Bhaven Sampat & Heidi L. Williams, *How Do Patents Affect Follow-On Innovation? Evidence from the Human Genome*, 109 AM. ECON. REV. 203, 203 (2019) (finding that gene patents have no effect on follow-on innovation). *See also* Janet Freilich & Sepehr Shahshahani, *Measuring Follow-On Innovation*, RSCH. POL’Y, Nov. 2023, at 3–4 (showing that the effect of patents on follow-on innovation will differ depending on the industry and context of the innovation).

measure the impact of different reforms. Note that we summarize—but do not endorse—various policy approaches suggested by others.

Organizationally, we begin with policies targeting ex ante reform—that is, reforms that would affect patents before grant—and then proceed to policies addressing ex post reform—those that would affect patents after grant. This division between ex ante and ex post reforms is typical of patent law scholarship. It arises from the observation that, while every patent application is examined at the Patent Office, only a small number (perhaps 1.5-2%) are litigated after grant.⁷⁰ Some scholars therefore favor reforms targeting the Patent Office because those reforms would affect every patent application.⁷¹ Other scholars note that Patent Office reforms are expensive (because they affect every patent application), and because the overwhelming majority of patents have no economic importance and are ignored, most low-quality patents may simply have no impact.⁷² It may therefore be more cost-effective to avoid ex ante reform at the Patent Office and instead craft policies that target only those patents with economic importance—for instance, patents that are litigated.⁷³

1. Pre-Grant Reforms

Some policy proposals target incentives to file patent applications at the Patent Office. The process is expensive—in 2015, attorneys charged on the order of \$15,000 to draft a U.S. patent application,⁷⁴ and the Patent Office also charges fees.⁷⁵ The expense of filing a patent serves as a “costly screen” for low-private-value patents—those that are worth less to their owners than the cost of patent application and subsequent expected renewal⁷⁶ and enforcement costs—and, to the (limited) extent that low-private-value patents overlap with low-quality patents, increased fees deter these patents.⁷⁷

After an application is filed, a patent examiner reviews the application and evaluates whether it meets the requirements for patentability, including whether it

70. Lemley, *supra* note 47, at 1497; Jean O. Lanjouw & Mark Schankerman, *Characteristics of Patent Litigation: A Window on Competition*, 32 RAND J. ECON. 129, 131 (2001).

71. E.g., Frakes & Wasserman, *supra* note 39, at 981.

72. Lemley, *supra* note 47, at 1496.

73. *Id.*

74. Gene Quinn, *The Cost of Obtaining a Patent in the US*, IPWATCHDOG (Apr. 4, 2015, 3:05 PM), <https://ipwatchdog.com/2015/04/04/the-cost-of-obtaining-a-patent-in-the-us/id=56485/> [https://perma.cc/J277-HEB8].

75. USPTO, *USPTO Fee Schedule* (Jan. 17, 2024), <https://www.uspto.gov/learning-and-resources/fees-and-payment/uspto-fee-schedule#Patent%20Fees> [https://perma.cc/8MQV-WSTH].

76. The USPTO requires payment of maintenance fees at certain intervals after patent grant. USPTO, *Maintain Your Patent*, <https://www.uspto.gov/patents/maintain> [https://perma.cc/HXG3-PA6P] (last visited Feb. 19, 2024).

77. Masur, *supra* note 7, at 690; see also Gaétan de Rassenfosse & Adam B. Jaffe, *Are Patent Fees Effective at Weeding Out Low-Quality Patents?*, 27 J. ECON. & MGMT. STRATEGY 134, 134-35 (2017); Florian Schuett, *Inventors and Impostors: An Analysis of Patent Examination with Self-Selection of Firms into R&D*, 61 J. INDUS. ECON. 660, 666 (2013) [hereinafter Schuett, *Inventors and Impostors*]; Florian Schuett, *Patent Quality and Incentives at the Patent Office*, 44 RAND J. ECON. 313, 315 (2013).

is new, useful, nonobvious, adequately disclosed, and claims patentable subject matter.⁷⁸ Examiners are thought to make many errors, resulting in frequent grant of patents that are not, in fact, patentable.⁷⁹ Increasing the rigor of examination could more accurately exclude patents that do not meet legal criteria for validity and include those that do.⁸⁰

Specific proposals for more rigorous examination include allocating additional time to examiners who currently spend an average of only nineteen hours per application.⁸¹ Examiners might, given more time, be able to review the contents of each application more carefully and conduct a more thorough search of the prior art.⁸² Others suggest decreasing examiner turnover⁸³ or incorporating peer review.⁸⁴ Increased retention may also allow for the use of long-term incentives to improve examiner performance, including those that reward quality instead of quantity.⁸⁵ Better training and improved organizational structure could prevent grant of some poor-quality patents,⁸⁶ as could changing examiner pay structure so that they do not have a financial incentive to quickly resolve applications, or limiting the availability of continuations.⁸⁷

Another approach to improving patent quality is to raise barriers to patent grant. This could be done by increasing issuance fees or charging penalties for

78. 35 U.S.C. §§ 101–03, 112.

79. Janet Freilich, *Ignoring Information Quality*, 89 FORDHAM L. REV. 2113, 2130 (2021).

80. E.g., Schuett, *Inventors and Impostors*, *supra* note 77, at 668.

81. In interviews with examiners, they “consistently expressed the need for additional time. This was stated mostly in concern to not being able to do a high-quality examination and to avoid taking short-cuts.” Michael D. Frakes & Melissa F. Wasserman, *Is the Time Allocated to Review Patent Applications Inducing Examiners to Grant Invalid Patents? Evidence from Microlevel Application Data*, 99 REV. ECON. & STAT. 550, 550 (2017).

82. *Id.*

83. See, e.g., Kevin M. Baird, *Business Method Patents: Chaos at the USPTO or Business As Usual?*, U. ILL. J.L. TECH. & POL’Y 347, 355–56 (2001); Michael J. Meurer, *Patent Examination Priorities*, 51 WM. & MARY L. REV. 675, 700 (2009).

84. Beth Simone Noveck, *Peer to Patent: Collective Intelligence, Open Review, and Patent Reform*, 20 HARV. J.L. & TECH. 123, 124–25 (2006); Lisa Larrimore Ouellette, *Pierson, Peer Review, and Patent Law*, 69 VAND. L. REV. 1825, 1836 (2016).

85. For instance, conditioning examiner bonuses on the outcomes of random quality reviews. Schuett *Patent Quality*, *supra* note 77, at 330.

86. William Matcham & Mark Schankerman, *DP18334 Screening Property Rights for Innovation*, CEPR Discussion Paper No. 18334 (2023), <https://cepr.org/publications/dp18334> [<https://perma.cc/4LPZ-KFSV>].

87. NAT’L ACAD. OF PUB. ADMIN., U.S. PATENT AND TRADEMARK OFFICE: TRANSFORMING TO MEET THE CHALLENGES OF THE 21ST CENTURY 102 (2005) (explaining that examiner incentives encourage them to allow applications); Michael D. Frakes & Melissa F. Wasserman, *Does the U.S. Patent and Trademark Office Grant Too Many Bad Patents?: Evidence from a Quasi-Experiment*, 67 STAN. L. REV. 613, 616 (2015) (exploring the PTO’s incentive to clear its backlog by granting patents early and thereby “biasing its grant rate upward”); Mark A. Lemley & Kimberly A. Moore, *Ending Abuse of Patent Continuations*, 84 B.U. L. REV. 63, 65 (2004) (recommending limiting continuations); Robert P. Merges, *As Many as Six Impossible Patents before Breakfast: Property Rights for Business Conceptions and Patent System Reform*, 14 BERKELEY TECH. L.J. 577, 607 (1999) (noting that “bonus points” are available for examiners who allow patent applications).

patents that do not meet criteria for grant.⁸⁸ An additional possibility is to strengthen substantive legal standards, as some scholars argue that the barriers for obtaining a patent are so low that poor quality patents would be granted even if examiners were to perfectly implement legal standards.⁸⁹ Further, if legal rules were closer proxies for patent quality, examiners, if they could properly implement those rules, would be better able to avoid granting low-quality patents.

2. Post-Grant Reforms

Patents expire twenty years after their initial filing date.⁹⁰ Although granted patents are presumed to be valid and enforceable, third parties can challenge a patent's validity or enforceability.⁹¹ Patent invalidation is a common outcome of litigation, but only about 1.5-2% of patents are ever challenged, and the vast majority (approximately 90%) of these cases settle without court invalidation.⁹²

Scholars concerned with poor patent quality have long sought increased opportunities for post-grant review of patents.⁹³ Congress heeded those calls, and in 2011, it implemented new pathways for the PTO to review the validity of granted patents.⁹⁴ These pathways are alternatives to litigation and allow patent validity to be reviewed substantially more quickly and cheaply than possible in a court proceeding.⁹⁵ Further, there are no standing requirements, meaning that—unlike

88. Neel U. Sukhatme, “Loser Pays” in Patent Examination, 54 HOUS. L. REV. 165, 165 (2016).

89. A commonly suggested reform is the expansion of restrictions on patentable subject matter to prevent patenting of certain categories of inventions. Menell, *supra* note 9, at 498 (“[T]he magnitude of the U.S. patent system’s failings in particular technological fields . . . could justify patentable subject matter exclusions.”); Meurer & Strandburg, *supra* note 56, at 577 (“Patentable subject matter doctrine should be used to identify those types of subject matter for which the social costs of patent protection are so high that the increased inventive steps that can be induced by offering a patent are simply not worth the costs imposed by patenting.”).

90. 35 U.S.C. § 154. Under some circumstances, patent term is adjusted or extended. 35 U.S.C. §§ 154, 156.

91. 35 U.S.C. § 282.

92. The frequency with which patents are invalidated in litigation depends on the sample studied. *See, e.g.*, John R. Allison & Mark A. Lemley, *Empirical Evidence on the Validity of Litigated Patents*, 26 AIPLA Q.J. 185, 205 (1998) (finding 46% of litigated patents invalid); Shine Tu, *Invalidated Patents and Associated Patent Examiners*, 18 VAND. J. ENT. & TECH. L. 135, 151 (2015) (finding 35% of litigated patents invalid). John R. Allison, Mark A. Lemley & David L. Schwartz, *Understanding the Realities of Modern Patent Litigation*, 92 TEX. L. REV. 1769, 1787 (finding that the challenger wins in about 42.4% of invalidity suits).

93. *Patent Quality Improvement: Post-Grant Opposition: Hearing Before the Subcomm. on Courts, the Internet, and Intellectual Prop. of the H. Comm. on the Judiciary*, 108th Cong. 29 (2004); 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, 994 (2004); Stuart J.H. Graham & Dietmar Harhoff, *Separating Patent Wheat from Chaff: Would the US Benefit from Adopting Patent Post-Grant Review?*, 43 RES. POL’Y 1649, 1649 (2014);

94. Leahy-Smith America Invents Act, Pub. L. No. 112-29, 125 Stat. 284 (2011) (codified as 35 U.S.C. §§ 311-19) (inter partes review procedures); 35 U.S.C. § 321 (covered business methods; these provisions expired in 2020 and have not been renewed); 35 U.S.C. §§ 321-29 (post-grant review).

95. Rochelle Cooper Dreyfuss, *Giving the Federal Circuit a Run for Its Money: Challenging Patents in the PTAB*, 91 NOTRE DAME L. REV. 235, 284 (2015).

litigation—anyone can challenge patent validity.⁹⁶ The proceedings have proven popular and have indeed resulted in the invalidation of many patents.⁹⁷ Scholars continue to debate the parameters of the proceedings.⁹⁸

Scholars also have numerous proposals for improving patent quality by changing rules governing litigation and licensing of patents. For instance, fee shifting in litigation could increase the cost of asserting low-quality patents and therefore reduce their value.⁹⁹ Various reforms to procedural rules that reduce litigation costs by providing mechanisms to resolve cases before discovery and allow early dismissal of baseless claims likely make it more difficult to assert low-quality patents.¹⁰⁰ With respect to licensing, antitrust rules can restrict certain uses (for instance, pay-for-delay settlements) which may reduce the value of low-quality patents.¹⁰¹

As is clear from the quantity and breadth of reform proposals, we are adrift in a sea of policy choices. Without an analytical model to understand and quantify the effects of these proposals, it is difficult to properly compare the costs and benefits of these widely varying policies.

C. *The Problems with Traditional Policy Assessments*

As should be apparent from the summary above, proposals for change are ubiquitous. Assessing whether to adopt these proposals and which to prioritize presents two interrelated challenges: understanding the effect of a policy change on all parts of the patent system and quantifying those effects. Here, we explain how the effects of policy proposals are traditionally explored and quantified. We then note the problems with traditional assessments—the questions that they cannot answer—and in the following Section, we discuss how our approach improves on the traditional method of assessing policy proposals.

Thoughtful advocates of particular patent reforms sometimes offer a model that supports their proposal, but more often, they offer an intuition that may be supported by empirical research. High-quality empirical research provides evidence of a causal link between a reform and some outcome variable that arguably is a

96. *Id.*; See also Brian J. Love, Shawn P. Miller & Shawn Ambwani, *Determinants of Patent Quality: Evidence from Inter Partes Review Proceedings*, 90 U. COLO. L. REV. 67, 68 (2019) (finding that IPR proceedings have succeeded in reducing the number of low-quality patents).

97. Colleen Chien, Christian Helmers & Alfred Spigarelli, *Inter Partes Review and the Design of Post-Grant Patent Reviews*, 33 BERKELEY TECH. L.J. 817, 817 (2018).

98. *Id.*; see also Andrei Iancu, Michael Fleming & C. Maclain Wells, *Indefiniteness in Inter Partes Review Proceedings*, 98 J. PAT. & TRADEMARK OFF. SOC'Y 4, 5 (2016); Stephen N. Kulhanek, *Inter Partes Review and Federal Litigation: Parallel Proceedings and Inconsistent Results*, 90 ST. JOHN'S L. REV. 1093, 1100 (2017).

99. Kieff, *supra* note 13, at 1953–54. *But see* Mark Schankerman & Florian Schuett, *Patent Screening, Innovation, and Welfare*, 89 REV. ECON. STUD. 2101, 2126 (2022) (finding that fee shifting decreases social welfare).

100. Paul Gugliuzza, *Quick Decisions in Patent Cases*, 106 GEO. L. REV. 619, 624 (2017).

101. Herbert Hovenkamp, *Antitrust and the Patent System: A Reexamination*, 76 OHIO ST. L.J. 468, 512 (2015) (suggesting that patents used in pay-for-delay settlements are “generally” low quality).

proxy for social welfare. For instance, one notable study of patent reform conducted by Filippo Mezzanotti focused on a 2006 Supreme Court case, *eBay v. MercExchange*,¹⁰² that revolutionized remedies in patent law.¹⁰³ *eBay* reduced the availability of injunctions in patent cases, which patent owners feared greatly diminished the value of their patents and firms targeted by patent suits hoped would lessen their losses in litigation.¹⁰⁴ Mezzanotti created a measure of the extent to which publicly traded American firms were “exposed” to *eBay*, that is, the extent to which firms were at risk of being sued for patent infringement and possibly enjoined.¹⁰⁵ Using standard econometric methods,¹⁰⁶ he provided evidence that the reduction in the probability of injunctive relief that followed from *eBay* caused an increase in R&D expenditures and high value patenting.¹⁰⁷

Related work by Mezzanotti and Simcoe provides evidence that the *eBay* decision did not reduce venture capital activity and did not harm productivity or slow overall R&D investment.¹⁰⁸ Another study by Appel, Farre-Mensa, and Simintzi shows that state anti-troll laws (aimed at reducing frivolous or unmeritorious lawsuits by so-called “trolls” seeking to profit from quick settlement) had a positive effect on employment by high-tech start-ups at risk of being sued for patent infringement.¹⁰⁹ The authors used the staggered adoption of state laws that regulate the use of settlement demand letters by patent owners who may seek to profit from frivolous assertion of patent rights to identify the causal effect of state anti-troll laws.¹¹⁰

This research and other similar high-quality empirical tests of patent policies help evaluate the impact of these policies. Here, these studies make the case that social harm possibly caused by patent trolling may be mitigated either by removing the presumption that a successful patent plaintiff is entitled to injunctive relief or by introducing regulations that discourage frivolous demand letters.

While useful and informative, this type of empirical work leaves open questions about the policies it evaluates. For example, this approach can only assess the performance of reforms after they have been adopted. Our method can be used to study reforms before they are implemented. Further, their methods do not allow them to measure the social welfare benefits of reforms. We also cannot tell how these policies relate to one another. While both *eBay* and anti-troll laws are thought

102. *eBay Inc. v. MercExchange, L.L.C.*, 547 U.S. 388 (2006).

103. Filippo Mezzanotti, *Roadblock to Innovation: The Role of Patent Litigation in Corporate R&D*, 67 *MGMT. SCI.* 7362, 7362–63 (2021).

104. *Id.*

105. *Id.*

106. A difference-in-differences analysis.

107. Mezzanotti, *supra* note 107.

108. Filippo Mezzanotti & Timothy Simcoe, *Patent Policy and American Innovation after eBay: An Empirical Examination*, 48 *RES. POL'Y* 1271, 1271 (2019).

109. Ian Appel, Joan Farre-Mensa & Elena Simintzi, *Patent Trolls and Startup Employment*, 133 *J. FIN. ECON.* 708 (2019).

110. *Id.*

to reduce frivolous litigation, they may target distinct kinds of behavior: *eBay* may be effective against well-funded litigants with large patent portfolios and potentially credible assertions, while the state laws may be effective against so-called “bottom-feeders” who do not have a credible threat of litigating and merely seek nuisance settlement payments.¹¹¹ These papers cannot compare the policies or tell us anything about potential interactions between the policies.

To recap, current policy assessment fails to assess reforms before they are implemented, fails to analyze the interaction of reforms, and fails to determine which reforms deserve the highest priority. These are vital questions in assessing when and how to implement patent policy.

II. A MODEL TO INFORM PATENT REFORM

In this Part we offer an extended, but informal, discussion of a theoretical model of patent examination and litigation that generates an intuitive understanding of how various policy instruments effect patent quality on their own and collectively. Most of our discussion is derived from formal analysis presented in an article by Schankerman and Schuett.¹¹² The model helps us uncover interactions between different parts of the patent system and allows us to trace the direct and indirect effects of policy changes on the patent system, including how such changes may affect seemingly unrelated aspects of the system. In some cases, the model yields ambiguous predictions about whether a policy change improves social welfare. Even when the model gives an unambiguous prediction about the direction of the change, it does not provide information about the magnitude. Clearly, a method of quantifying the magnitude of the social welfare effect of policy changes would be helpful to better evaluate patent reform. Our analysis illustrates such a method in Part II.C. In Part III we show how the theoretical insights from the model can be combined with our novel numerical results to assess reforms that impact patent quality.

A. The Model

We start with a baseline model that is rich enough to capture the interaction of policy instruments on four aspects of the patent system, but simple enough so that we can explicitly characterize equilibrium behavior and extract intuitions about how various policy instruments influence patent quality. We hope to persuade readers that our policy analysis is plausible by complicating the model in various ways to see if our results are robust, and by calibrating the model so that it generates results that quantitatively match the behavior of the American patent system.

111. Mark A. Lemley & A. Douglas Melamed, *Missing the Forest for the Trolls*, 113 COLUM. L. REV. 2117, 2126 (2013) (discussing different types of trolling behavior).

112. Mark Schankerman & Florian Schuett, *Patent Screening, Innovation, and Welfare*, 89 REV. ECON. STUD. 2101, 2110 (2022).

We model high and low patent quality by supposing that certain *high-type* inventions have high invention cost and are not expected to be profitable unless the inventor gets a patent. Some pharmaceutical drugs, for example, are expensive to develop and innovators may not be able to charge prices high enough to recoup research costs without a patent.¹¹³ *Low-type* inventions have low invention cost and investment in this type of invention generates positive expected profit in the absence of a patent, but naturally, profits are higher with a patent, and inventors of low-type inventions may find it is profitable to bear the cost of patent prosecution and the risk that their patent application may be denied or that their granted patent may be invalidated. Certain software inventions may fall into this category—in some circumstances, innovations in software do not need patent protection to generate a profit,¹¹⁴ but companies developing new software nonetheless frequently file for patent protection.¹¹⁵

The model focuses on the nonobviousness requirement which is generally regarded as the most important of the patentability requirements.¹¹⁶ We implement this standard by classifying low-type inventions as obvious and high-type inventions as nonobvious. This follows the approach in caselaw which characterizes the obviousness standard as a method for “weeding out those inventions which would not be disclosed or devised but for the inducement of a patent.”¹¹⁷ In the baseline model, the Patent Office makes mistakes, but courts do not.¹¹⁸ We suppose that the Patent Office always grants a patent on high-type inventions and makes mistakes by sometimes granting patents on low-type inventions.¹¹⁹ Specifically, the Patent Office correctly denies patents on low-type inventions with probability e and mistakenly grants patents on low-type inventions with probability $1 - e$. The parameter e measures examination intensity; if e is high, then the probability of mistake is low.

We capture strategic behavior by inventors and competitors in a game-theoretic model that has three stages. In the first stage a potential inventor learns

113. See, e.g., Benjamin N. Roin, *Unpatentable Drugs and the Standards of Patentability*, 87 TEX. L. REV. 503, 503 (2009).

114. See, e.g., Ronald J. Mann, *Do Patents Facilitate Financing in the Software Industry?*, 83 TEX. L. REV. 961, 979–81 (2005) (explaining why software inventions can often be profitable without patent protection).

115. James Bessen & Robert M. Hunt, *An Empirical Look at Software Patents*, J. ECON. & MGMT. STRATEGY 157, 157 (2007) (finding that software patents comprise fifteen percent of all patents).

116. E.g., Robert W. Harris, *Prospects for Supreme Court Review of the Federal Circuit Standards for Obviousness of Inventions Combining Old Elements*, 68 J. PAT. & TRADEMARK OFF. SOC'Y 66, 66 (1986) (“[O]bviousness is the most frequently dispositive patentability issue . . .”).

117. *Graham v. John Deere Co.*, 383 U.S. 1, 11 (1996). This is discussed further in Abramowicz & Duffy, *supra* note 56, at 1593.

118. In the baseline model courts always invalidate patents on low-type inventions and never invalidate patents on high-type inventions when they are asked to render a judgment. We discuss court errors and the tradeoff between litigation cost and accuracy in Part III.C. The results are robust to allow for court errors. Schankerman & Schuett, *supra* note 112, at 2134.

119. The model can be generalized to allow for errors with respect to both high and low type applications.

whether a research project would lead to a high- or low-type invention and decides whether to invest in invention, whether to pay the cost of applying for a patent, and, if the patent is granted, whether to pay the issuance fee (and subsequent maintenance fees). In the second stage, if no patent is granted then the competitor will use the new technology without paying license fees (secrecy is not feasible), and the game ends. If a patent is granted the patent owner will offer a license to the potential competitor. In the third stage, the potential competitor chooses whether to accept the license and use the invention according to the terms of the license, or instead push the parties to court. Importantly, the competitor *does not know* whether an invention is a high- or low-type and thus does not know whether a patent is valid.¹²⁰

Equilibrium

We can identify a unique, simple, and intuitive equilibrium that satisfies rationality requirements and other standard assumptions used in game theory.¹²¹ In this baseline model we make certain assumptions about various parameters including the value of the inventions and the cost of developing them; later we will comment on how equilibrium behavior changes as key parameters change. Please note that the definition of the high- and low-type inventions depends on a comparison of the private value of an unpatented invention to the cost of developing the invention. It is certainly possible that a particular high-type invention has higher or lower private value than a particular low-type invention. In other words, the reader should not assume high-type inventions are necessarily high value inventions.

Stage One: Decision to develop the invention and file a patent:

High-type inventions. The potential inventor invests in R&D only if the expected costs of invention, patent prosecution, and patent litigation are not too great.¹²² Given an invention, the firm applies for a patent and pays the required fees.

Low-type inventions. The potential inventor always invests in R&D and obtains an invention. The firm does not apply for a patent if patent examination errors are infrequent and if the costs of patent prosecution, post-grant fees, and litigation are too high. If errors are common, meaning that low-type patents may be

120. Like the Patent Office, the competitor does not know the inventor's innovation cost and thus does not know whether a patented invention is a high type or low type. The competitor does know the examination intensity and thus the rate of mistakes at the Patent Office, as well as the fraction of low- and high-type inventions in the population of potential inventors. We suppose the competitors use this information and their observation of inventors' behavior to form rational beliefs about whether a particular patent is valid or not.

121. The equilibrium concept is "perfect Bayesian equilibrium," which requires that players' beliefs satisfy Bayes' Rule, and that players' actions are optimal at every stage of the game.

122. There is heterogeneity within the group of high type inventors; some of those inventors do not expect to make enough profit to justify investing even in inventions with patents because the frictions associated with patent approval and litigation are too large compared to net patent profits. The article by Schankerman and Schuett explains how the equilibrium changes over a broad range of parameter values. Schankerman & Schuett, *supra* note 112, at 2126.

granted, and costs are low compared to the private value of the invention, then the firm will apply for a patent and pay post-grant fees if a patent is granted.¹²³

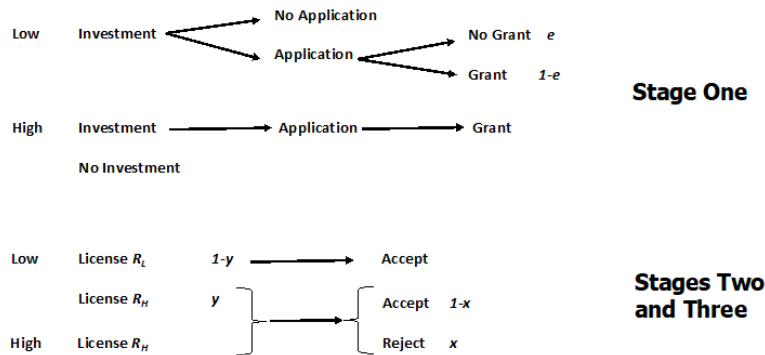
Stage Two: Patent grant; decision to license:

High-type inventions. Given an invention and patent the inventor will offer a patent license and ask for a high net payment R_H from the competitor.

Low-type inventions. Given no patent, the competitor will use the invention and the inventor will not be compensated. Given a patent, the inventor will either offer a patent license and ask for a low net payment R_L from the competitor with probability $1 - y$ or instead imitate the offer made by the owner of a high-type invention (bluffing behavior) and offer a patent license with a high net payment R_H from the competitor with probability y . The low net payment will be set just below the competitor's expected litigation costs, thus preempting challenges.

Stage Three: Competitor's behavior. The competitor accepts a patent license asking for a net payment of R_L because it is lower than the cost of challenging the patent in court. The competitor will be indifferent between accepting or rejecting a license asking for a net payment of R_H and will choose to litigate with probability x and accept the license with probability $1 - x$. Following rejection of the license the parties will bear litigation costs and a court will determine whether the patent is valid. If the patent is found valid, the inventor will repeat the license offer asking for a net payment of R_H , and the competitor will accept because otherwise the competitor will use the invention without making a payment to the inventor.

Figure 3: Equilibrium of the Investment, Patenting, Licensing, and Litigation Game



123. There is heterogeneity within the group of low-type inventors; some of those inventors do not expect to make enough profit from patenting to take the risk of applying for a patent on an invention that might be rejected by the Patent Office or invalidated in court.

Figure 3 displays equilibrium behavior. The top of the figure shows Stage One behavior for low types and high types, and the bottom of the figure shows Stages Two and Three behavior. In Stage One, the low type always invests in R&D because that investment is profitable regardless of patenting, but the high type may be discouraged from investing if patent fees or expected litigation costs are high. If the high type invents, then it always applies for a patent, which is always granted. Whether the low type applies for a patent depends on fees and examination intensity; given an application the low type gets a patent if the Patent Office makes a mistake. At Stage Two, the high type always makes the settlement offer R_H , and the low type bluffs by making the same settlement offer with probability y , and with the complementary probability of $1 - y$ it makes the lower settlement offer of R_L . At Stage Three, the competitor always accepts an offer of R_L and finds it equally profitable to either accept an offer of R_H or refuse that offer and litigate. In equilibrium, the competitor litigates with probability x and accepts an offer of R_H with probability $1 - x$.¹²⁴

We draw four main lessons from this modelling exercise. First, despite a patent-based reward that is sufficient to cover the R&D costs of high-type inventions, high-type invention may be *chilled* because of the frictions created by expected litigation costs. We indicate this possibility in Figure 3 by showing that at Stage One the high-type inventor might not invest in R&D. Second, inventors of certain low-type inventions are *deterred* from patenting by the rigors of examination. If inventors of low-type inventions pursue patents, then the Patent Office will detect a fraction e of those applications as being of low quality and reject them. This is shown in the top right portion of Figure 3.

The other two lessons are drawn from behavior displayed in the bottom of Figure 3. One lesson is that nuisance value settlements arise endogenously in our model. If a patent owner makes a settlement offer of R_L , then the competitor correctly infers the invention is obvious and the patent is invalid. Because the competitor could reject settlement, pay its litigation cost, invalidate the patent, and avoid licensing fees, the patent owner *preempts* a possible validity challenge and collects the corresponding nuisance value from a settlement license. The final lesson is that settlement negotiations may break down and litigation may occur because inventors of low-type inventions who receive patents may try to *bluff* competitors by acting as if they have high-type inventions. This bluffing strategy is captured by the probability y shown in the bottom left of Figure 3. Litigation may occur

124. Notice that the competitor is indifferent between accepting an offer R_H and litigating, and the low-type inventor is indifferent between making an offer R_H , and offer of R_L . Given their indifference, these parties are willing to randomly choose between equally profitable options. Constraints imposed by the requirement that the beliefs of the competitor are rational, and that the parties choose actions that maximize expected profits, given their mutual understanding of equilibrium behavior, pin down the probabilities of x and y .

following a settlement offer of R_H because the competitor finds that litigation and accepting the settlement offer are equally profitable in equilibrium.¹²⁵

B. Applications of the Model: Theoretical Predictions

To illustrate how our model can be used to evaluate patent reform we consider two stylized reforms: reduced litigation costs and increased examination intensity. Our goal here is to show that even simple reforms may have direct and indirect effects that ripple through the patent system. One might expect that reduced litigation cost would increase patent challenges and thereby improve patent quality. Likewise, one might expect that more rigorous examination would improve patent quality. These intuitions may be correct, but one should not jump to these conclusions without exploring the equilibrium adjustments to the policy changes through our model.

Several reforms have targeted patent litigation cost, including the creation of low-cost proceedings at the Patent Office on questions of patent validity,¹²⁶ and the creation of “Markman hearings” early in patent trials to deal with often case-dispositive questions of how claim terms should be interpreted.¹²⁷ For now, let us abstract from the details of these reforms because they affect more than litigation cost. We assume the government can directly reduce patent litigation cost (for example, with a subsidy). We examine more realistic policies that trade off litigation cost for accuracy in Part III.C.

How would parties respond to reduced litigation cost? One effect is that a competitor facing an unfavorable settlement offer of R_H would have a stronger desire to litigate than settle. Of course, this is the basis of the simple intuition that there will be more challenges. But owners of patents on low-type inventions would have a stronger desire to preempt patent challenges by making a favorable settlement offer of R_L to avoid the increased risk of litigation (even though the cost of litigation has fallen). Given this adjustment by owners of patents on low-type inventions, competitors should reconsider their choice between litigation and settlement when they face an offer of R_H if they believe the odds of winning a

125. Competitors correctly perceive that the mix of inventors demanding a licensing payment of R_H is such that litigation offers the same expected profit to the competitor as accepting the license. This makes the competitor willing to randomize over litigation and licensing. In turn, the probability x of litigation limits the profitability and appeal of an offer of R_H to owners of patents on low-type inventions. This leaves owners of patents on low-type inventions indifferent between bluffing and preempting a patent challenge by offering a nuisance value patent license.

126. Dreyfuss, *supra* note 95, at 239.

127. The name “Markman hearing” comes from the Supreme Court’s decision in *Markman v. Westview Instruments*, which held that claim construction is a question of law, not fact, and can therefore be decided by a judge. 517 U.S. 370, 391 (1996). Subsequently, courts began holding claim construction proceedings early in the litigation process in order to resolve ambiguity in claim terms. *Ballard Med. v. Allegiance Healthcare Corp.*, 268 F.3d 1352, 1357 (Fed. Cir. 2001). These decisions are often case dispositive and, if not, help streamline the remainder of the case by narrowing the number of potential arguments.

challenge would fall because of less bluffing by low types. Surprisingly, it is not easy to establish that the intuition that there will be more challenges is correct.

Even if reduced litigation cost causes more challenges, we have more work to do before we could conclude such a reform increases social welfare. Why? Because challenges impose social costs and indirect effects arise from more patent challenges. One indirect effect is the increase in preemptive settlements that preserve patents on low-type inventions and the associated deadweight loss caused by restricted output. Another possible negative indirect effect could be reduced development of inventions by high types who might have to pay higher expected litigation costs (even though the cost of an individual patent challenge declines, the increased frequency of trials could increase expected litigation cost). The quantification methods that we describe in Part II.C help us resolve questions that the model leaves unresolved—does the frequency of challenges increase, and does this reform increase social welfare?

We finish this Section by considering a reform that increases examination intensity and thereby reduces the frequency of improper patent grants on low-type inventions.¹²⁸ In our model and in Figure 3, increased examination intensity amounts to an increase in e and a reduction in the grant rate for applications covering low-type inventions. If that were the only effect, then clearly patent quality would improve. But better screening by the Patent Office changes the mix of patents that reach the licensing and litigation stages of the model and possibly reduces the frequency of challenges. If challenges are less frequent, then low types have more to gain from a patent grant and might be more willing to apply for a patent. Greater examination intensity deters inventors of low-type inventions from applying, but a greater reward from less frequent challenges could more than offset that effect. This equilibrium adjustment on propensity to file a patent could mute the positive effect on patent quality flowing from increased examination intensity.¹²⁹

Supposing that increased examination intensity does indeed improve patent quality, does that always translate into improved social welfare? Not necessarily. A complete analysis requires determining how the rate of litigation changes and quantifying the social welfare change associated with it. Changes in the rate of litigation indirectly effect the incentive of inventors of high-type inventions to invest in development of their inventions; for example, more frequent litigation would discourage marginal inventors from developing their inventions. Finally, one must account for the impact of the change in the rate of litigation on the frequency of nuisance value settlements and the associated social harm.

128. Many such policies have been proposed by scholars, with discussions of how the policies will affect the accuracy of examiners' decisions. *See supra* Part I.

129. It is also possible that inventors of low-type inventions are deterred and reduce their filing of patent applications because they do not want to risk paying the filing fee and getting nothing in return. In this case, the direct effect of increased examination intensity is augmented by the decision of more inventors to forego patent applications on low type inventions.

We return to our policy assessment of reforms that reduce litigation cost and increase examination intensity in Part III.A; we combine the theoretical insights from this model with quantitative analysis to develop rigorous analysis of leading reforms. Here our goal was to show that parties are likely to respond to policy reforms in various ways at different points in the patent system. This means that policies that offer a direct and beneficial effect on patent quality may not in fact have that effect when equilibrium adjustments are accounted for. We do not mean to overstate this point. There are policy reforms that robustly deliver improved patent quality and social welfare gains in the context of our model. But also, we offer a warning that simple intuitions often are not reliable.

C. Applications of the Model: Empirical Predictions

In the previous Section, we explained how our model can be used to obtain theoretical predictions about policies' effects. As we showed briefly above—and will return to in more complex examples in Part III—theoretical predictions are often ambiguous. Theory does not provide information about the *magnitude* of the response. Policies have many different effects, with some improving and others diminishing social welfare. Size of a response is therefore a crucial piece of information for policymakers for two reasons. First, where responses to a policy change move behavior in different directions or are ambiguous, quantifying the magnitude of each response enables policymakers to calculate the direction of the overall response. Second, even where a response unambiguously moves in one direction, the size of the response is key.

This Section explains how our model can be coupled with data to gain predictions about the magnitude of a policy's effects. We begin by explaining our methodology and then, in Part III, apply it to specific policy questions.

To make these empirical predictions, an economic model must include mathematical equations relating different parts of the model and entities' behavior. The model we set out above does not have these equations and deriving them is beyond the scope of this paper. Rather, we turn to an already-published, validated model created by two of us and use the equations from that model to conduct new quantification experiments, the results of which we provide in Part III.¹³⁰ Our goal, therefore, is not to provide readers with every mathematical detail but instead to overview how quantification works and how it can be fruitfully applied in the policy context. For interested readers, more details are provided in Appendix A.

To use a formal model such as the one in Part II.A to assess the impact of policy reforms, we first need to estimate the underlying parameters of the model. The model consists of several equations that simultaneously generate the key (equilibrium) outcomes. These predictions depend, of course, on the values of the parameters; we therefore need to estimate them. The key outcomes predicted by the model we use here are the equilibrium grant rate, litigation rate, patent

130. Schankerman & Schuett, *supra* note 112, at 2106.

validation rate in the courts, research and development expenditures per invention, and productivity.

The building blocks of the model for which we need to estimate parameters are the examination cost functions, the distribution of invention size (value), and the distribution of invention development costs. In addition to the *estimated* parameters for these relationships, we have a set of parameters which we assign based on external information, including the level of product demand and cost, obsolescence rate, discount factor, statutory patent life, litigation cost function, and pre-grant and post-grant patent fees. Details of how we set these external parameters are provided in Appendix A.

Estimation is done by choosing the set of parameters that generate equilibrium (predicted) outcomes that exactly match the observed empirical targets.¹³¹ The empirical targets and sources of external data to compute these targets are outlined in the table below; additional details of how we measure the empirical targets for estimation are provided in Appendix A. To validate the model, we conducted five external checks by comparing implications of our calibrated model against external information that played no role in its estimation. These strongly validate our baseline calibration results.¹³²

Empirical Target	Data Sources for the Empirical Target
Grant rate: the number of granted patents divided by the number of applications.	The grant rate is based on 2.15 million patent applications covering cohorts 1996-2005. ¹³³

131. That is, grant rate; litigation rate; patent validation rate in the courts for patent challenges; research and development expenditures per invention; productivity growth per invention; the USPTO budget per application examined; and the elasticity of the examination cost function.

132. The external validations were conducted in Schankerman & Schuett, *supra* note 112, at 2134–36. First, we compared the *estimated* share of high-type inventions from our model to survey evidence on the percentage of innovations that would not have been developed without patent protection. Edwin Mansfield, *Patents and Innovation: An Empirical Study*, 32 MGMT. SCI. 173, 173 (1986). Second, we compared the ratio of licensing revenue to R&D costs implied by our model with the evidence on the U.S. corporate sector. Carol A. Robbins, *Measuring Payments for the Supply and Use of Intellectual Property*, in INTERNATIONAL TRADE IN SERVICE AND INTANGIBLES IN THE ERA OF GLOBALIZATION 139, 140 (Marshall Reinsdorf & Matthew J. Slaughter eds., 2009). Third, we compared the implied elasticity of patent applications with respect to pre-grant fees, based on our baseline calibration, to econometric estimates in the literature. Gaetan de Rassenfosse & Bruno van Pottelsberghe, *On the Price Elasticity of Demand for Patents*, 74 OXFORD BULL. ECON. & STAT. 58, 58 (2012). Fourth, we calculated the impact of changes in R&D on the number of patent grants in equilibrium and compare the implied elasticity from our baseline calibration to econometric estimates from the literature. Nicholas Bloom, Mark Schankerman & John Van Reenen, *Identifying Technology Spillovers and Product Market Rivalry*, 81 ECONOMETRICA 1347, 1347 (2013); Bronwyn Hall, Zvi Griliches & Jerry A. Hausman, *Patents and R&D: Is There a Lag?*, 27 INT'L ECON. REV. 265, 265 (1986). Finally, we used our estimated parameters to compute the cost of processing a patent application under a pure registration system, where there was no examination, and compared it to computations of the cost savings of eliminating examination using USPTO patent operations' budget information.

133. Michael Carley, Deepak Hegde & Alan Marco, *What is the Probability of Receiving a U.S. Patent?*, 17 YALE J.L. & TECH. 203, 207 (2015).

Litigation rate: the number of litigated patents divided by the number of grants.	The litigation rate is the percentage of granted patents for domestic corporate entities in the U.S., over the period 1978-1999, that are involved in at least one suit. This corresponds to the probability that a randomly drawn patent is involved in litigation at least once. ¹³⁴
Validation rates: the number of challenges won by the patentee divided by the number of litigated patents.	We use the fraction of patent challenges in which the validity of all contested claims in the patent is upheld by the court. ¹³⁵ Data covers all cases filed in U.S. district courts for 2008-2009.
Research and development cost per invention: private sector R&D spending per invention.	Research and development cost per invention is constructed for each (3-digit) manufacturing sector (based on the North American Industrial Classification System (NAICS)) and then aggregated using the number of patent grants. ¹³⁶ For the latter, we use the number of patent grants at the sector level (constructed by the USPTO) and divide by the grant rate to estimate patent applications by sector. ¹³⁷ We then adjust by estimates of the patent propensity for each sector, based on the large survey of U.S. corporations by Cohen et al. 2000. ¹³⁸
Productivity growth per invention: total factor productivity growth (TFP, which corresponds to the expected cost reduction) generated by patent applicants.	TFP growth per invention is constructed for each (6-digit, NAICS) manufacturing sector, averaged over the period 1987-2007, and then aggregated using the number of patent grants for each sector. The productivity measure is the multifactor productivity index based on capital, production workers, non-production workers, and energy and non-energy materials, constructed by the U.S. Bureau of the Census (NBER-CES Manufacturing Industry Database). ¹³⁹ For the number of inventions, we use the same measure as described

134. Lanjouw & Schankerman, *supra* note 70, at 135–36.

135. Allison, Lemley & Schwartz, *supra* note 92, at 1796.

136. Schankerman & Schuett, *supra* note 112, at 2129.

137. U.S. Patent and Trademark Office Patent Technology Monitoring Team, U.S. Patenting Trends by NAICS Industry Category, Utility Patent Grants 1963-2012, U.S. Pat. & Trademark Off. (last visited February 2023), https://www.uspto.gov/web/offices/ac/ido/oeip/taf/naics/doc/naics_info.htm [<https://perma.cc/BX68-BSD7>].

138. Wesley M. Cohen, Richard R. Nelson & John P. Walsh, *Protecting Their Intellectual Assets: Appropriability Conditions and Why U.S. Manufacturing Firms Patent (Or Not)*, NBER Working Paper 7552 at 1 (2000), <https://www.nber.org/papers/w7552> [<https://perma.cc/A3XQ-EU8X>].

139. Schankerman & Schuett, *supra* note 112, at 2132.

	under research and development cost per invention above.
Patent Office cost per application.	Constructed from USPTO reports on labor and other costs for patent operations. ¹⁴⁰
Elasticity of the examination cost function.	Constructed using information on grant rates for examiners at different seniority levels. ¹⁴¹ Details are provided in Appendix A.

To get a better intuitive understanding of how quantification works, consider the five empirical targets we can compute corresponding to five equilibrium outcomes predicted by the model: the grant rate, litigation rate, validation rate in challenges, R&D per invention, and total factor productivity growth per invention. Using publicly available information (described in the table above), we construct a measure of each of these outcomes. Each of these corresponds to a *specific number*—for example, the grant rate is 0.712, litigation rate is 0.0171, and so on. In the model, each of these outcomes is a (complicated) function of the five parameters to be estimated, as discussed previously. Imagine choosing an arbitrary set of values for the five parameters. These would imply a *specific value* for each of the five outcomes whose actual values we have measured. If the outcomes predicted by the model when evaluated at these parameter values exactly match the five empirical outcomes we measure, then that set of parameter values corresponds to the “true values”. If the predicted outcomes do not match exactly all of the empirical outcomes, then we iterate by changing the values of the parameters until we find the set of parameter values for which the predicted and actual outcomes *do match*.¹⁴²

III. AN INTEGRATED FRAMEWORK FOR ASSESSING PATENT REFORM

This Part takes the formal model and techniques introduced above—using an integrated, equilibrium framework to make theoretical predictions and complementing those predictions with quantified empirical calculations—and applies them to various reforms. In doing so, we show that a rigorous approach

140. *Id.*

141. Michael Frakes & Melissa Wasserman, *Is the Time Allocated to Review Patent Applications Inducing Examiners to Grant Invalid Patents? Evidence from Microlevel Application Data*, 99 REV. ECON. & STATS. 550, 554 (2017).

142. Here, we provide an illustrative example using a single equation (but note that the true method involves a system of equations): Suppose we knew that the share of high types among applicants is l . Then the grant rate is $GR = l + (1-l)(1-e)$: all high types (whose share is l) pass examination, and a fraction $(1-e)$ of the low types (whose share is $1-l$) pass examination because the Patent Office detects only a fraction (e) of them. Hence, the examination intensity required to match a given observed grant rate is $e = (1-GR)/(1-l)$. Using $GR = 0.712$ and $l = 0.399$, we obtain $e = 0.479$. This example is merely illustrative; in reality, the share of high types among applicants, which we were taking as given here, is a function of the various parameters, in particular the distribution functions of R&D costs and invention values, as well as examination intensity itself. The calibration method consists of numerically solving a system of equations to find the parameters that make the model predictions line up with all of the empirical targets.

embedding the analysis of patent reform in an integrated framework that accounts for linkages, optimizing behavior, and strategic interaction can produce surprising results. Our goal is to convince scholars and policymakers of the importance of using such approaches when evaluating policies.

The range of policies that can be analyzed with our framework is vast, so our discussion below is illustrative, not comprehensive, and focuses on several examples of prominent policy reforms. The Sections below are organized in keeping with the traditional structure of patent scholarship, which typically focuses either on ex post reforms—ways to improve quality after patents have been granted—or ex ante reforms—methods to avoid granting low-quality patents in the first place. Accordingly, Part III.A examines several ex post policies and Part III.B ex ante policies. Our integrated framework shows that the conventional divide between pre- and post-grant reforms is incomplete, as changes to pre-grant outcomes will affect the post-grant stage and vice versa. Part III.C discusses combinations of reforms, including one which has both a pre- and post-grant component, and illustrates how changes at both the pre- and post-grant stages have broad implications across the patent system.

A. Post-Grant Reforms

As explored in Part I, there are many proposals for post-grant patent reform.¹⁴³ In this Section we use the methodology described in Part II to engage in three prominent policy debates. First, we ask whether patent litigation settlement should be regulated to improve alignment between the private interests of patent litigants with the public interest.¹⁴⁴ Second, we ask whether remedies should be adjusted to mitigate the harm caused by low patent quality.¹⁴⁵ Third, we ask whether shifting the litigation cost and accuracy trade-off could improve the performance of the patent system.¹⁴⁶

1. Restraints on Private Settlement

One oft-discussed aspect of the design of ex post review systems is whether private settlement should be permitted under any circumstances, or whether it is beneficial to restrict or prohibit it to better align the outcomes of private litigation with the public interest.¹⁴⁷ We first briefly summarize scholarship and case law on this policy, emphasizing that both have primarily considered its effects on just one part of the patent system: litigation. We then broaden our discussion to the patent system as a whole and explain that restraints on private settlement affect not only

143. *Supra* Section I.B.1.

144. *Infra* Section III.A.1.

145. *Infra* Section III.A.2.

146. *Infra* Section III.A.3.

147. *See generally* Owen M. Fiss, *Against Settlement*, 93 YALE L.J. 1073, (1984) (identifying procedural reforms intended to promote settlement even though settlement outcomes may diverge from public interests).

litigation, which is intuitive, but also seemingly unconnected elements of the system, such as the decision to file high- and low-type patents or the structure of equilibrium license contracts (including negotiated royalty rates).

Restraints on private settlement have long been a theme of scholarly discussion. As a baseline, private parties are generally free to settle litigation on whatever terms they please.¹⁴⁸ However, if settlement agreements prevent competition, they may violate antitrust laws.¹⁴⁹ This is a particularly challenging question in the context of patents because patents are granted by the government to give patentees the right to exclude competitors and are not, simply on that basis, an antitrust violation.¹⁵⁰ For more than a century, therefore, courts and scholars have fretted over the proper balance between patent and antitrust law.¹⁵¹ A topic of frequent concern has been how much freedom to give to parties when they craft a patent license to settle a lawsuit.¹⁵²

Recently, antitrust regulation of settlement licenses has been repeatedly considered in the context of pharmaceutical patent litigation, with the Supreme Court weighing in in *FTC v. Actavis*.¹⁵³ These cases arise when a generic firm attempts to enter a new drug market before the relevant patents have expired.¹⁵⁴ Predictably, the incumbent patent owner sues, and sometimes the parties engage in prolonged and expensive litigation challenging patent validity.¹⁵⁵ Many of these disputes settle with the patent owner paying the generic to drop out of the market or to delay entry.¹⁵⁶ This unusual practice, rarely seen in other settings, has been labeled pay-for-delay or reverse payment settlement.¹⁵⁷ The FTC has asked courts to ban these settlements as per se illegal.¹⁵⁸ In *Actavis*, the Court rejected a per se approach in favor of rule of reason analysis that allows courts to balance the social

148. There are some exceptions. *E.g.*, Tobias Barrington Wolff, *Managerial Judging and Substantive Law*, 90 WASH. U. L. REV. 1027, 1048 (2013) (explaining that judges supervise settlement in class actions); Howard M. Erichson, *The Role of the Judge in Non-Class Settlements*, 90 WASH. U. L. REV. 1015, 1015 (2013) (exploring the role of judges in non-class aggregate settlements).

149. Harry M. Reasoner & Scott J. Atlas, *The Settlement of Litigation as a Ground for Antitrust Liability*, 50 ANTITRUST L.J. 115, 115–16 (1981).

150. Erik Hovenkamp, *Antitrust Law and Patent Settlement Design*, 32 HARV. J.L. & TECH. 417, 418 (2019).

151. William E. Kovacic, Robert C. Marshall & Michael J. Meurer, *Patents and Price Fixing by Serial Colluders*, 10 N.Y.U. J. INTEL. PROP. & ENT. L. 152, 161–162 (2021). *See also* Louis Kaplow, *The Patent-Antitrust Intersection: A Reappraisal*, 97 HARV. L. REV. 1813, 1815 (1984) (“The intersection of antitrust law and patent policy have proved to be a source of perpetual confusion and controversy since the passage of the Sherman Act nearly a century ago.”).

152. Kovacic, Marshall & Meurer, *supra* note 151, at 161.

153. *FTC v. Actavis, Inc.*, 570 U.S. 136 (2013).

154. *Id.* at 140–45.

155. *Id.* at 143.

156. *Id.* at 136.

157. *Id.* at 136–37.

158. Kwame Mensah, *Are Reverse-Payment Settlement Agreements Per Se Unlawful and Anticompetitive, or Per Se Lawful Unless Determined to Be the Result of Sham Litigation?*, 40 PREVIEW U.S. SUP. CT. CASES 259, 260 (2012).

gains from litigation settlement (reducing overall litigation costs) against the costs from output restrictions supported by potentially invalid patents.¹⁵⁹

Both the *Actavis* decision and significant scholarship recognize the potential impact of settlement rules on patent quality.¹⁶⁰ However, the discussion tends to focus on one aspect of the patent system: litigation. For instance, an amicus brief signed by over one hundred professors and the American Antitrust Institute argued that unrestricted settlements could prevent challenges to weak (low-type) patents.¹⁶¹ Other work similarly focused on how settlement rules affect incentives and ability of challengers to seek patent invalidation.¹⁶² The general thrust of this scholarship and caselaw is that unrestricted settlements allow private parties to settle before a court has decided the question of patent validity, meaning that a low-type patent that should be invalidated might escape unscathed.¹⁶³ Rules either banning or restricting certain types of patent settlements promote litigation of more cases through to judgment, and they increase the likelihood that courts will have the opportunity to invalidate low-type patents.¹⁶⁴

As the courts' and scholars' focus suggests, restrictions on settlement could clearly affect how low-type patents are treated in litigation and settlement. However, given the importance of the policy and the amount of scholarly attention it has received, it is important to consider whether it also affects other parts of the patent system. Using our model, we suppose that antitrust, or possibly some other regulatory approach, could be used to limit the output restriction and profit gains that may arise from unregulated settlement. As suggested by Figure 4, this reform may impact the patent system in many ways.

159. Michael A. Carrier, *The Rule of Reason in the Post-Actavis World*, 2018 COLUM. BUS. L. REV. 25, 37 (2018).

160. *FTC v. Actavis*, 570 U.S. at 154. John R. Allison, Mark A. Lemley & Joshua Walker, *Patent Quality and Settlement among Repeat Patent Litigants*, 99 GEO. L.J. 677, 680 (2010); Bronwyn H. Hall, Stuart Graham, Dietmar Harhoff & David C. Mowery, *Prospects for Improving U.S. Patent Quality via Postgrant Opposition*, 4 INNOVATION POL'Y & ECON. 115, 125-26 (2004); Herbert Hovenkamp, *Antitrust and the Patent System: A Reexamination*, 76 OHIO ST. L.J. 467, 512 (2015).

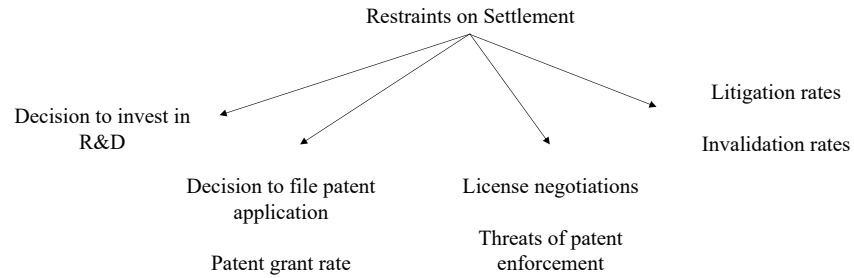
161. Brief Amici Curiae of 118 Law, Economics, and Business Professors and the American Antitrust Institute in Support of Petitioners at 17, *FTC v. Watson Pharm., Inc. et. al.*, 570 U.S. 136 (2013) (No. 12-416).

162. See, e.g., Crane, *supra* note 28, at 700; Hovenkamp, *supra* note 28, at 1720–21; Shapiro, *supra* note 28, at 395.

163. See, e.g., *FTC v. Watson Pharm., Inc.*, 677 F.3d 1298, 1305–06 (11th Cir. 2012) (summarizing arguments that reverse payment settlements unlawfully restrained competition because, in the absence of a settlement, the court likely would have found the patent invalid).

164. Brief for 118 Law, Economics, and Business Professors and the American Antitrust Institute as Amici Curiae Supporting Petitioners at 17, *Fed. Trade Comm'n v. Actavis, Inc.*, 570 U.S. 136 (2013).

Figure 4: Restraints on Settlement Can Affect Multiple Parts of the Patent System



Restraints on settlement may have indirect effects on the terms of the license agreements that parties reach, negotiation in the shadow of litigation, and even on the decision to develop an invention. To understand this, let us provide more detail on how license contracts are structured in our model. We assume that the contracting parties use license terms that feature both a running royalty and a lump-sum payment. In the absence of restrictions on contracting, the owners of low-quality patents who preempt challenges optimally use high-running royalties to make the licensee a less effective competitor, thereby softening competition and raising joint profits. In order to get the licensee to agree to such a contract, the patent holder must “compensate” them by selecting a negative lump-sum payment, that is, a reverse payment.

If reverse payments are prohibited, then a low type who wants to preempt a validity challenge must reduce the running royalties to induce the competitor to accept a license when it knows it could successfully challenge the patent. Lower royalties intensify competition, reducing prices and deadweight loss. However, this also means that the payoff from preempting challenges has become relatively smaller, compared to the payoff from bluffing. In order to return the model to equilibrium, the rate at which competitors file challenges when they receive a high license fee offer (which could stem either from a high type or a bluffing low type) must go up. The resulting increase in litigation lowers high types’ payoff from innovation, leading marginal high-type inventors to refrain from developing their inventive ideas. At the same time, because marginal low types are those with low-value inventions which are not exposed to challenges, their application behavior is unchanged. The theoretical analysis thus predicts that restrictions on settlements reduce patent quality, as measured by the share of high types among patentees.

The theory, however, says nothing about the magnitude of the effect on patent quality. Moreover, even though patent quality decreases, the impact on *social welfare* is more complex, and the theoretical analysis does not make a clear prediction as to whether welfare rises or falls. Welfare falls because of increased litigation cost and because some high-type inventions are not developed. Welfare grows because more

low-quality patents are successfully challenged and because regulation of settlement licenses moderates the anti-competitive effect of preemptive licenses offered by owners of low-quality patents.

We think state-of-the-art policy analysis should respond to ambiguous theoretical results with a quantification exercise. We do that now—our calibrated model simulates the impact of a reform that prohibits lump-sum license payments from the patent owner to the competitor. This policy is a sensible way, in the context of our model, to illustrate the issue at stake in *Actavis*.¹⁶⁵

Table 1 reports the highlights from our simulation. The first row gives results for the unregulated baseline simulation and the second row gives results for the simulation with the reform. We can see from the first column that patent quality does not change noticeably. This indicates that the extent to which high types decide not to invest in developing an invention, although theoretically and qualitatively present, is quantitatively small, so the percentage of patents granted to high types hardly changes.¹⁶⁶ The third columns show that, as expected, the litigation rate increases, and the second column indicates that low types do not change their rate of preemptive license offers.¹⁶⁷

165. Here, we use our analytical model to explore one policy governing settlement: a ban on reverse payment settlements. But the question of appropriate restraints on settlements is an active area of scholarship with many different potential policy approaches. Many commentators have endorsed a laissez-faire approach in which any settlement agreement is permissible, meaning that any contract term in a patent license is acceptable and immune from antitrust review. Others take a less extreme approach and recognize that some restrictive practices, for example, territorial division, that might be condemned as per se illegal in other settings are permissible in patent licenses. Other licensing practices, such as a licensing contract that requires the licensee to pay royalties even if they do not use the patented technology, have been condemned for wrongly expanding the scope of a patent. This allows the firms to raise the price to the monopoly level, regardless of the cost reduction that the invention enables. Each of these variations on settlement policies could be evaluated using the methods described in this Article.

166. The reduction in high-type innovation and patenting is so small that the share of high-type patents decreases only in the second decimal, which is not visible in the table due to rounding.

167. This result can be explained in terms of our model. The rate of preemptive licensing is pinned down by our equilibrium; it takes on a value that leaves the competitor indifferent between accepting a license or litigating given an offer of R_H . Profit from accepting the license does not change because the license associated with R_H does not include a negative, fixed fee even in the unregulated case. This means that, for bluffing to stay the same, the competitor's expected profit from litigation should not change. This is the case if the probability that the court invalidates the patent does not change. From the first column, we see that the mix of low- and high-type patents does not change; thus, the competitor's probability of winning a validity challenge does not change, and hence, the frequency of bluffing does not change either.

Table 1. Restraints on Settlement License Terms

Simulation	Patent Quality (share of high-type patents)	Preemptive Settlement	Litigation rate	Change in overall welfare relative to baseline
Baseline (current policies)	56.0%	66.9%	1.7%	--
No negative fixed fees	56.0%	66.9%	2.1%	3.6%

The final column in Table 1 indicates that banning negative fixed fees in patent licenses could dramatically improve social welfare—by 3.6% in this simulation. Big gains accrue because preemptive licenses restrict industry output less. Consumers gain more than the firms lose even when accounting for increased litigation cost. The appeal of this reform only becomes apparent with the aid of our simulation; as we explain above, the theoretical results from our model are ambiguous. The quantification shows that the benefits of reduced deadweight loss by far outweigh the costs of increased litigation costs.

2. Remedies

A leading goal of patent reformers has been to modify patent remedies to mitigate the harm caused by low patent quality.¹⁶⁸ In 2006, the Supreme Court noted these concerns in *eBay* and reduced the availability of injunctive relief to remedy patent infringement.¹⁶⁹ Before *eBay*, injunctive relief was nearly automatic in cases decided before the patent expired, meaning that patent owners could block infringers from future use, sale, and manufacture of the patented technology.¹⁷⁰ The threat of injunction puts a patentee in a strong bargaining position in license negotiations with potential, actual, and losing defendants.¹⁷¹ After *eBay*, an injunction is no longer the presumptive remedy, and courts often instead award patentees damages for ongoing infringement, which is thought to be an inferior remedy for the patentee.¹⁷²

168. E.g., Ian Ayres & Paul Klemperer, *Limiting Patentees' Market Power Without Reducing Innovation Incentives: The Perverse Benefits of Uncertainty and Non-Injunctive Remedies*, 97 MICH. L. REV. 985, 1020 (1999); Donald Chisum, *Reforming Patent Law Reform*, 4 J. MARSHALL REV. INTELL. PROP. L. 336, 339–40 (2005); Lemley & Shapiro, *supra* note 35, at 2035.

169. *eBay v. MercExchange, L.L.C.*, 547 U.S. 388, 394 (2006).

170. John Golden, *Patent Trolls and Patent Remedies*, 85 TEX. L. REV. 2111, 2113 (2006).

171. Lemley & Shapiro, *supra* note 35, at 2044.

172. Mark Schankerman & Suzanne Scotchmer, *Damages and Injunctions in Protecting Intellectual Property*, 32 RAND J. ECON. 199, 199 (2001).

Like restraints on private settlement, modification of remedies has a variety of effects on behavior both before and after patent grant. Reducing the availability of injunctions improves the competitor's bargaining position in settlement negotiations. The opposite is true for the patent owner. The net effect on litigation and licensing (including challenge preemption by low types) is unclear. It is clear, however, that the expected value of patents declines because options for patent enforcement are limited, which could induce low types (where inventions are also low value) to apply for fewer patents and high types to decline to develop an invention in more cases. While scholarship has traditionally focused on how modification of remedies affects litigation,¹⁷³ our integrated model shows much broader effects.

However, relying on our model alone, we cannot tell whether reducing the availability of injunctions causes social welfare to rise or fall. Quantification is therefore necessary. In the calibrated model, we interpret the *eBay* decision as reducing the likelihood that a patentee can get an injunction.¹⁷⁴ In the baseline model, we assume the patentee can always get an injunction. In the counterfactual analysis we explore two different possibilities: in the "low impact" case, we suppose that the probability of an injunction declines by 25%, and in the "high impact" case, we suppose the probability of an injunction declines by 58%.¹⁷⁵ We emphasize again that patentees not only lose value after a successful patent lawsuit but also when they negotiate the licensing payment R_H .¹⁷⁶

173. E.g., Bernard H. Chao, *After eBay, Inc. v. MercExchange: The Changing Landscape for Patent Remedies*, 9 MINN. J.L. SCI. & TECH. 543, 543 (2008); John M. Golden, *Patent Trolls and Patent Remedies*, 85 TEX. L. REV. 2111, 2113 (2006); Christopher B. Seaman, *Permanent Injunctions in Patent Litigation after eBay: An Empirical Study*, 101 IOWA L. REV. 1949, 1949 (2015).

174. Kirti Gupta & Jay P. Kesan, *Studying the Impact of eBay on Injunctive Relief in Patent Cases* 14 (Univ. of Ill. Coll. of L. Legal Studies Research Paper No. 17-03, 2016), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2816701 [<https://perma.cc/APF6-TJBB>].

175. We compute two estimates of the likelihood of an injunction after *eBay* that differ according to what we assume about patentees who sought an injunction before *eBay* but do not do so after *eBay*. The "Low eBay" estimate assumes that patentees who no longer seek an injunction do not need one to extract the license fee. After *eBay*, 75% of patentees who seek an injunction obtain one; before *eBay*, we assume that 100% of them received one. So, the decline in the likelihood of getting an injunction is 25%. The "High eBay" estimate assumes that patentees who originally sought an injunction but do not after *eBay* were discouraged from seeking it due to *eBay*. We assume that they would not have obtained an injunction had they sought one. This gives us an implied decline of 58%. Gupta and Kesan report that the average proportion of patentees who litigate and seek an injunction declined from 7.7% before *eBay* in 2006 to 4.3% in the five years after it. Gupta & Kesan, *supra* note 174. Conditional on filing a motion to enjoin, the probability of obtaining a permanent injunction fell from nearly 100% before *eBay* to about 75% after it. Colleen V. Chien & Mark A. Lemley, *Patent Holdup, the ITC, and the Public Interest*, 98 CORNELL L. REV. 1, 9-10 (2012). According to the assumptions on which we base the "High eBay" estimate, 7.7% of patentees would like an injunction (as before *eBay*) but only $4.3\% \times 0.75 = 3.225\%$ actually get one. So, the decline is $(7.7 - 3.225) / 7.7 = 58\%$.

176. We make the strong assumption that absent an injunction, the competitor can use the patented invention for free. This overstates the impact of *eBay* because successful plaintiffs are normally entitled to damages. We also assume that, with or without an injunction, the patent owner and competitor ultimately negotiate a license unless the patent is invalidated.

Table 2 reveals interesting contrasts from Table 1. Whereas settlement restraints did little to change patent quality, our stylized version of the *eBay* reform has a dramatic effect on patent quality in our simulation. This vividly illustrates the importance of an integrated analysis of reform and shows that a post-grant reform may substantially influence pre-grant behavior. We also find little change in preemptive settlement combined with a significant decline in litigation. On balance, there is a small improvement in social welfare.

Table 2. Reduced Availability of Injunctive Relief

Simulation	Patent Quality (share of high-type patents)	Preemptive Settlement	Litigation rate	Change in overall welfare relative to baseline
Baseline (current policies)	56.0%	66.9%	1.7%	--
<i>eBay</i> (low impact)	51.9%	67.5%	1.3%	0.2%
<i>eBay</i> (high impact)	43.6%	68.6%	0.6%	0.1%

Supporters of *eBay* praised the case as a means to weaken opportunistic patent assertions by making it harder to extract rents from low-quality patents. But our results suggest that high-type inventors were hurt more than low types, in the sense that their applications declined relatively more (leading to a decrease in the share of high-type patent grants). That we nevertheless find the policy to be welfare-enhancing can be explained by the fact that it reduces litigation: as inventors are forced to leave more rent to competitors, the incentive to challenge patents declines.

We are surprised the social welfare gain from *eBay* is so small compared to the settlement restraint inspired by *Actavis*—between 0.1-0.2% versus 3.6%. Our result appears to clash to some extent with empirical work outlined in Part I.C, indicating that *eBay* may have caused an increase in R&D by firms at risk of being sued for patent infringement without harming patent owners.¹⁷⁷ But perhaps the apparent clash is somewhat illusory. The other empirical work does not measure or make claims about social welfare and does not make use of the equilibrium of a model

177. Mezzanotti, *supra* note 103, at 7362; Mezzanotti & Simcoe, *supra* note 108, at 1271.

that integrates invention development and patenting decisions with litigation and licensing decisions.¹⁷⁸

3. Tradeoff Between Cost and Accuracy in Litigation

A fundamental challenge in litigation, both in patent cases and other areas of law, is finding the optimal trade-off between cost and accuracy.¹⁷⁹ Courts could (perhaps) get an entirely correct answer to all factual disputes in cases, but the cost would likely be very high because many questions would require in-depth investigation. Courts and other adjudicatory bodies therefore take shortcuts which, by design, reduce accuracy but yield cost savings. Take, for example, inter partes review of patents, a procedure where patent validity can be challenged at the Patent Trial and Appeals Board (PTAB), an adjudicatory body at the Patent Office.¹⁸⁰ Patents can be invalidated for many reasons, but the PTAB considers only two: anticipation (the invention is not new) and obviousness (the invention is obvious).¹⁸¹ Further, the party bringing the challenge can only present two types of evidence of anticipation or obviousness: patents and printed publications, even though other types of evidence also can be used to invalidate patent claims in district court (for example, public use or on offer to sell the invention).¹⁸² Finally, the PTAB allows only limited discovery.¹⁸³ These measures reduce the accuracy of PTAB adjudication, but they also significantly reduce cost—proceedings at the PTAB are about 90% cheaper for the parties involved than litigation.¹⁸⁴

Many other doctrinal and procedural choices in the design of patent law affect the balance between cost and accuracy. For example, the well-known choice of whether substantive doctrine takes the form of a rule or a standard is linked to the cost-accuracy trade-off.¹⁸⁵ Most doctrines governing the law of invention novelty take the form of rules.¹⁸⁶ Rules are less fact dependent, more error prone, but cheaper and easier to litigate.¹⁸⁷ Procedural choices in patent law determine whether an issue can be disposed of early at trial on a motion to dismiss or at summary

178. Another possibility is that courts have implemented *eBay* in a way that is sensitive to the social value of the invention, or the proximity of a patent found valid to the threshold for a finding of obviousness. If so, the unintended chilling effect on the incentive of high types to develop their inventions would be reduced.

179. *E.g.*, Kaplow, *supra* note 44, at 557.

180. *Inter Partes Review*, U.S. PAT. & TRADEMARK OFF. (2022), <https://www.uspto.gov/patents/ptab/trials/inter-partes-review> [<https://perma.cc/EL78-KYUN>].

181. *Id.* See also 35 U.S.C. §§ 102, 103.

182. 35 U.S.C. § 311(b).

183. Dreyfuss, *supra* note 95, at 259.

184. Anne Layne-Farrar, *The Other Thirty Percent: An Economic Assessment of Duplication in PTAB Proceedings and Patent Infringement Litigation 1* (July 2017), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2994858 [<https://perma.cc/9BNG-MGGH>].

185. Kaplow, *supra* note 44, at 557.

186. David O. Taylor, *Formalism and Antiformalism in Patent Law Adjudication: Rules and Standards*, 46 CONN. L. REV. 417, 484 (2013).

187. Kaplow, *supra* note 44, at 594.

judgment.¹⁸⁸ Early dispositive rulings typically allow the parties to avoid trial costs, especially discovery costs, but these early rulings are potentially less accurate.¹⁸⁹ Many federal district courts have implemented procedural rules that require both sides to provide contentions with information about validity and infringement arguments at the beginning of the case.¹⁹⁰ This too allows faster and cheaper disposition of cases, but without discovery, which may reduce accuracy.¹⁹¹

Combining the cost-accuracy trade-off and the patent quality problem presents fascinating but difficult policy questions. Inaccurate courts are less helpful in correcting quality problems, but reduced litigation cost makes it more likely that competitors will access the courts to challenge invalid patent claims. We hope by now our readers will recognize that we also need to consider the indirect effects on pre-grant behavior that might arise when the cost-accuracy trade-off is changed. Our model does not give a simple theoretical prediction about how social welfare changes when patent litigation cost is reduced (along with accuracy). Thus, we investigate social welfare changes in three simulations.¹⁹²

Our simulation considers three different policies that reduce the cost of patent litigation and its accuracy compared to our baseline model. Recall that in the baseline model we suppose that patent courts do not make errors. In our stylized reforms we suppose that courts are rational, but they make errors because they reach decisions based on imperfect information. We allow errors in both directions; certain erroneous decisions rule that patents on low-type inventions are valid, and other erroneous decisions rule that patents on high-type inventions are invalid.¹⁹³ For all three reforms, we assume that accuracy declines by 25%, but we vary the extent of the associated cost reduction. The first reform assumes that cost declines by 25% (i.e., to the same extent as accuracy); the second reform assumes that costs decline by 33% (i.e., somewhat faster than accuracy); the third reform assumes that costs decline by 50% (i.e., considerably faster than accuracy). We explore a range of stylized policies because we do not know of any empirical work that could guide

188. Gugliuzza, *supra* note 100, at 622.

189. *Id.* (“[M]any of the recent changes in patent law . . . facilitate quicker decisions”); The Supreme Court’s decision in *Markman v. Westview Instruments*, which allowed judges to construe claims (interpreting the meaning of claims) as a question of law, also brought claim construction proceedings earlier in the case, saving substantial amounts of money and encouraging early settlement but perhaps sometimes decreasing accuracy if settlement occurs without the benefit of full discovery.

190. See Megan M. La Belle, *The Local Rules of Patent Procedure*, 47 ARIZ. ST. L.J. 63, 86 (2015).

191. *Id.* (noting that local patent rules were intended to reduce costs and delay).

192. Appendix B, *infra*.

193. The court is assumed to be Bayesian and update a prior based on a signal (evidence) they receive. The precision of the signal depends on how accurate the court is. Accuracy is modeled in roughly the same way as examination intensity except that there are both type I and type II errors (the Patent Office makes only one type of error). The court then compares the resulting posterior belief to the evidentiary threshold. In line with judicial practice, we assume the courts require clear and convincing evidence in order to invalidate a patent, which we implement by requiring the posterior belief that the patent is of low type to be above 75%.

our choices, and furthermore, the nature of the trade-off likely differs depending on the policy used to implement the new trade-off.

Table 3 displays the results from our simulations. It shows that neither the quality of granted patents nor the frequency of preemptive settlements changes appreciably. The third column shows that the rate of litigation increases as the cost of litigation declines. The fourth column shows a small gain in social welfare that is about the same for all three reforms.

Table 3. Tradeoff Between Litigation Cost and Accuracy

Simulation	Patent Quality (share of high-type patents)	Preemptive Settlement	Litigation rate	Change in overall welfare relative to baseline
Baseline (current policies)	56.0%	66.9%	1.7%	--
25% lower accuracy; 25% lower cost	56.0%	67.7%	2.0%	0.2%
25% lower accuracy; 33% lower cost	56.0%	68.0%	2.4%	0.2%
25% lower accuracy; 50% lower cost	55.9%	68.7%	3.5%	0.3%

There is a striking contrast between our simulated reforms reducing cost (and accuracy) and our simulated reform restraining the payment terms in settlement licenses. Neither simulated reform changed patent quality or the frequency of preemptive challenges much. Both simulated reforms increased litigation significantly, and one might think that increased litigation would translate into significant gains in social welfare because of more successful challenges to low-quality patents. Actually, social welfare grows ten times as much or more in the case of settlement restraint. Apparently, there is more to the story than simply tracking changes in the rate of litigation.

Two factors help explain this big difference. First, even though the frequency of preemptive challenges is the same across the simulations, the welfare consequences are quite different. Banning negative fixed payments brings big social welfare gains because the licensing parties are less able to restrict output and raise

prices. There is no comparable benefit from the reforms that reduce litigation cost. Second, there is little social benefit from the cost reduction policies in terms of reduced litigation cost per suit even in the simulation in which litigation costs are cut by 50%. The reason is that when litigation costs are cut in half, the frequency of litigation more than doubles, offsetting possible cost savings compared to the baseline.

Our finding with respect to litigation cost illustrates the value of a calibrated approach to evaluating policy proposals and doing so in an equilibrium framework which allows parties to adjust their behavior optimally when the environment (policy) changes. The results here run counter to previous scholarship that advocates for policies that reduce patent litigation costs, believing that despite a reduction in accuracy, reduced litigation costs will have a large impact. While we agree that reduced litigation costs increase social welfare, our simulations find, surprisingly, a small effect.

B. Pre-Grant Reforms

To complement our analysis of post-grant reforms we consider two pre-grant reforms in this Section: first, increasing examination intensity and second, making inventions claiming abstract ideas unpatentable.

1. Examination Intensity

Patent examiners can evaluate applications with varying levels of intensity. At one extreme is a registration system, where examiners do no substantive evaluation, and all applications are granted.¹⁹⁴ Although this is not widely favored currently, it was actually the practice in the U.S. for many years in the early nineteenth century.¹⁹⁵ The advantages of a registration system are that patents get granted quickly and the system is inexpensive for the Patent Office to run.¹⁹⁶ The disadvantages are that the system will attract low-quality applications, which will all be granted, meaning that the proportion of low-type patents will be high.¹⁹⁷

194. For a modern registration proposal, see F. Scott Kieff, *The Case for Registering Patents and the Law and Economics of Present Patent-Obtaining Rules*, 45 B.C. L. REV. 55, 69 (2003). See also Miriam Marcowitz-Bitton, Yotam Kaplan & Emily Michiko Morris, *Unregistered Patents and Gender Equality*, 43 HARV. J.L. & GENDER 48, 50 (2020) (proposing a system granting rights to unexamined patents that resembles the registration system as the term is used in this article).

195. The patent system functioned as a registration system from 1793 to 1836. Robert P. Merges, *The Hamiltonian Origins of the U.S. Patent System, and Why They Matter Today*, 104 IOWA L. REV. 2559, 2568 (2019).

196. Edward C. Walterscheid, *The Winged Gideon – An Early Patent Controversy*, 79 J. PAT. & TRADEMARK OFF. SOC'Y 533, 534 (1997) (noting that a registration system “had the distinctly laudatory and desirable advantage of minimizing the role of government and hence of governmental expense”).

197. Merges, *supra* note 195, at 2568 (“As might be expected from a pure registration system, patent quality was a serious issue.”).

At the other extreme, the Patent Office could conduct an intensive examination of applications leading to near-perfect decisions about patent grant.¹⁹⁸ Strengthening examination results in the increased detection and rejection of low-quality patent applications, and this also deters some low-type inventors from applying for a patent. Patents that survived examination would usually be high quality, so the overall mix of high- and low-quality patents would tilt toward the former. These effects reduce output restrictions and avoid deadweight loss. But higher examination intensity would be expensive—examiners would need extensive training and would spend considerable time on each application.

The debate about examination intensity is perhaps the most active policy debate in patent scholarship today.¹⁹⁹ The debate is framed by Mark Lemley's *Rational Ignorance at the Patent Office*, where Lemley observed that the Patent Office currently practices a relatively low level of examination because it does not have the resources to carefully review the flood of applications it must process. Received wisdom suggests that patent quality has therefore suffered.²⁰⁰ Perhaps more resources should be devoted to examination to improve patent quality.²⁰¹ Lemley countered by remarking that most patents have no commercial significance, and thus, it may be socially wasteful to spend much time on examination when quality can be monitored later in the courts.²⁰² Whereas every patent application is evaluated at the Patent Office, only a subset of commercially valuable patents are challenged with respect to validity in courts or quasi-judicial proceedings.²⁰³

Lemley suggests, therefore, that it is rational for the Patent Office to have low examination intensity—saving resources—and to essentially defer examination to courts if a patent is sufficiently important to be litigated.²⁰⁴ This proposal has been deeply influential²⁰⁵ but has also been countered by a broad range of scholarship proposing an increase in examination intensity.²⁰⁶ In summary, the debate about optimal examination intensity is active and unsettled.

198. Although some scholars dispute whether it is actually possible for the Patent Office to achieve near perfect results, suggesting that unsurmountable institutional constraints might prevent this. *See, e.g.*, Freilich, *supra* note 79, at 2117 (noting that examiners may not be able to prevent certain types of errors); Jason Rantanen, *The Malleability of Patent Rights*, 2015 MICH. ST. L. REV. 895, 895 (2015) (arguing that patent scope changes after grant, making it hard for patent examiners to get it right).

199. *See* Frakes & Wasserman, *supra* note 39, at 988 (explaining that the influence of an article by Mark Lemley framing the examination intensity debate is “incontestable. Lemley is the most frequently cited scholar in the field of intellectual property and [the article] is his most cited article.”).

200. Lemley, *supra* note 47, at 1502.

201. *Id.* at 1495–96 (“Several solutions have been proposed, but the common thread among them seems intuitively obvious: the PTO should do a more careful job of reviewing patent applications and should weed out more “bad” patents.”).

202. *Id.* at 1519.

203. *Id.* at 1497.

204. *Id.*

205. Frakes & Wasserman, *supra* note 39, at 988.

206. *Id.* *See also* Rai, *supra* note 40, at 1081 (arguing that Lemley's approach “suffers from several limitations”).

The discussion above—and most legal scholarship on patent policy—relies largely on “theory,” whether it be economic models, intuition, or other forms of reasoning. As we have noted, theoretical arguments can be improved by attaching real-world numbers to the predictions of the theory to quantify the effects of policy changes,²⁰⁷ and understanding the magnitude of a policy change can be critical to determine whether implementing the policy is worth the cost.

Some first steps in the direction of quantification have been taken in the “rational ignorance” debate. In 2001, Lemley compared the cost of doubling examination intensity to the associated savings on litigation of poor-quality patents and made back-of-the-envelope calculations showing that increased examination intensity was not justified.²⁰⁸ In 2019, Michael Frakes and Melissa Wasserman used rigorous empirical methods and performed their own calculation and came to the opposite conclusion.²⁰⁹ They found that doubling examination time would result in 19% fewer patent grants²¹⁰ and save \$244 million.²¹¹

By putting numbers to theoretical predictions, both studies were able to provide new insight about whether certain policies were desirable (albeit reaching different conclusions). We applaud these studies, but as we noted above, they are not based on the equilibrium of a formal model that integrates several phases of the innovation and patenting process, and they do not provide direct measures of the magnitude of the change in social welfare. We therefore use our model to revisit this important debate.

Table 4 displays a simulation investigating the impact of a reform that improves patent quality by significantly increasing examination intensity. In terms of our model, this translates into an increase in e , the probability that an examiner rejects an application claiming a low-type invention. In the baseline mode $e = 0.48$, and in the proposal with increased examination intensity $e = 0.83$. Our proposal involves a socially optimal increase in examination intensity (this is the examination intensity that maximizes social welfare in the baseline scenario). Looking back to Figure 3, notice that more applications on low-type inventions are rejected. Naturally, this decreases the appeal of applying for a patent on low-type inventions; thus, patent quality improves directly from better examination and indirectly by deterring low-quality applications.

207. For an overview of numerically calibrated models and an explanation of their importance, see Thomas F. Cooley, *Calibrated Models*, 13 OXFORD REV. ECON. POL'Y 55, 55 (1997).

208. Lemley, *supra* note 47, at 1502.

209. Frakes & Wasserman, *supra* note 39, at 975–76.

210. *Id.* at 985.

211. Like Lemley, Frakes and Wasserman also compared the cost of doubling examination intensity to associated savings in litigation, but two differences in the analyses are notable. First, Frakes and Wasserman reversed Lemley's assumption that increased examination intensity would lead to increased expenditure on patent prosecution. *Id.* Second, in lieu of a back-of-the-envelope calculation, Frakes and Wasserman extrapolate the relevant magnitudes from their empirical analysis and cost \$660 million. *Id.* at 1020. The savings from fewer patent grants would be \$904 million—composed of \$491 million of savings in litigation, \$112 million of savings at the PTAB, and fewer office actions that yield \$301 million in savings in prosecution costs. *Id.* at 1021.

Table 4. Increased Examination Intensity

Simulation	Patent Quality (share of high-type patents)	Preemptive Settlement	Litigation Rate	Change in overall welfare relative to baseline
Baseline (current policies)	56.0%	66.9%	1.7%	--
Registration System (no examination)	40.2%	72.1%	1.6%	-5.3%
Increased Examination Intensity	83.8%	56.5%	2.3%	3.0%

Changing the quality of granted patents influences licensing and litigation in stages Two and Three of the model. One might think that competitors would have a lower probability of invalidating a patent at trial and thus find litigation less appealing, but such reasoning is incomplete. Even though the fraction of granted patents that cover high-type inventions goes up, the probability of invalidating a patent at trial also depends on the frequency of bluffing by owners of patents on low-type inventions. If bluffing probability increases enough, then the probability of a successful challenge might increase. In addition, under the optimal policy, which involves not only larger e but also higher Patent Office fees, a larger fraction of patents are of high value and thus worth challenging.

In fact, our simulation reveals that the frequency of preemptive settlement declines, the complementary probability grows, and the litigation rates rise from 1.7% in the baseline case to 2.3% after examination intensity is increased. We also find that patent quality grows substantially, and social welfare grows by an impressive 3.0%.

Shifting gears, we also simulate the performance of a registration system in which examination intensity is set at zero. Compared to the baseline, patent quality

falls so much that nearly 60% of the patents granted cover low-quality inventions. The frequency of preemptive challenges by owners of low-quality patents grows to 72.1%, and social welfare falls by 5.3% compared to the baseline.

Rational ignorance appears to be a poor policy choice for those concerned about patent quality. It is important to recall, however, that the welfare gain from a post-grant reform, banning negative fixed fees in settlements, offers an even larger welfare gain of 3.6%, leading us to reject the notion that policymakers should systematically favor either pre-grant or post-grant reform when addressing patent quality problems.

2. Changes to Patentable Subject Matter

We now consider a second pre-grant reform to improve patent quality: screening out patent applications on abstract ideas. Certain types of inventions are categorically not patentable—including laws of nature, natural phenomena, and abstract ideas.²¹² In recent years, the Supreme Court has taken several cases that have expanded the set of inventions deemed to fall into these categories.²¹³ Scholars have hypothesized that many of these inventions would be developed in the absence of a patent grant (low-type inventions in our terminology) and should be categorically unpatentable,²¹⁴ while other scholars argue that expanding patentable subject matter rejections might discourage research on and disclosure of socially valuable inventions.²¹⁵ We use our calibrated model to test the social welfare impact of patentable subject matter restrictions.

Identifying and categorizing patent claims that cover an abstract idea is notoriously difficult; hence, the empirical grounding for this simulation is more speculative. We urge readers to be cautious about relying on these simulations and to treat them as only illustrative. That said, the general question we investigate is important in the context of the patent-quality debate. Specifically, we treat certain invention subject matter as a proxy for a set of inventions that are unlikely to require a patent as an incentive to develop the invention.²¹⁶

212. *Diamond v. Chakrabarty*, 447 U.S. 303, 309 (1980).

213. *Alice Corp., v. CLS Bank Int'l*, 573 U.S. 208 (2014); *Ass'n for Molecular Pathology v. Myriad Genetics, Inc.*, 569 U.S. 576 (2013); *Mayo Collaborative Servs. v. Prometheus Labs., Inc.*, 566 U.S. 66, 70–72 (2012); *Bilski v. Kappos*, 561 U.S. 593, 604–605 (2010).

214. *E.g.*, Rochelle C. Dreyfuss, *Are Business Method Patents Bad for Business?*, 16 SANTA CLARA HIGH TECH. L.J. 263, 263 (2000); Michael J. Meurer, *Business Method Patents and Patent Floods*, 8 WASH. U. J.L. & POL'Y 309, 309 (2002); Katherine J. Strandburg, *What If There Were a Business Method Use Exemption to Patent Infringement?*, 2008 MICH. ST. L. REV. 245, 246 (2008).

215. *E.g.*, Kevin Madigan & Adam Mossoff, *Turning Gold into Lead: How Patent Eligibility Doctrine is Undermining U.S. Leadership in Innovation*, 24 GEO. MASON L. REV. 939, 939 (2016); Xuan-Thao Nguyen & Jeffrey A. Maine, *Attacking Innovation*, 99 B.U. L. REV. 1687, 1687 (2019); Kristen Osenga, *Institutional Design for Innovation: A Radical Proposal for Addressing Sec. 101 Patent-Eligible Subject Matter*, 68 AM. U. L. REV. 1191, 1191 (2018).

216. Instead of subject matter, we might think of proxies for the obviousness of an invention like nearly simultaneous invention of the same subject matter by multiple parties or adapting a known process for implementation using the internet. Some of these proxies are already incorporated into the

Table 5. Screening for Abstract Idea Claims During Examination

Simulation	Patent Quality (share of high-type patents)	Preemptive Settlement	Litigation Rate	Change in overall welfare relative to baseline
Abstract idea baseline (low)	55.0%	66.7%	1.7%	--
No Abstract idea (low)	56.3%	66.5%	1.7%	1.9%
Abstract idea baseline (high)	53.0%	66.1%	1.8%	--
No Abstract idea (high)	56.9%	65.6%	1.8%	5.8%

In this simulation exercise, we assume that abstract idea inventions can be developed at no cost—in this sense, we treat them as an extreme case of low-type inventions. We also assume that the Patent Office can accurately identify these patent applications up front. Both assumptions make our estimated welfare gains an upper bound to what can potentially be achieved.

We ran two simulations in which we use a different computation about how many inventions are abstract ideas. The first pair of simulations have a lower frequency of abstract ideas (3%), and the second pair have a higher frequency (9%).²¹⁷ Roughly speaking, one can think of this reform as a variant of a reform that increases examination intensity. We assume that examiners can accurately identify and reject all abstract inventions ($e = 1$, for abstract inventions) but continue to have the baseline probability of rejecting applications on other low-type inventions ($e = 0.48$).

Similar to increased examination intensity, the subject matter reforms offer substantial increases in social welfare: 1.9% when the frequency of abstract idea

patent system. Dmitry Karshedt, *Nonobviousness: Before and After*, 106 IOWA L. REV. 1609, 1625 (2021).

217. We need to re-estimate the baseline model for each version because the distributions of development costs differ. The baseline model uses a particular (exponential) form for the distribution of costs, whose parameters we estimate. In addition to this, however, for the abstract ideas model we assume a share of patents (those based on abstract ideas) to have zero development costs. That share differs in the two versions.

inventions is lower and 5.8% when the frequency is higher. Patent quality improves and neither the frequency of preemptive licenses nor litigation change much. The examination intensity simulation produced more dramatic improvements in patent quality, a significant increase in the rate of litigation, and a significant decline in preemptive licenses. We attribute the difference to an increase in applications on low-type inventions that are *not* abstract ideas. The overall fraction of applications on low-type inventions declines in the new simulations, but not nearly as much as it does in the simulation with increased examination intensity.²¹⁸

Of course, we want to emphasize that if some inventions based on abstract ideas are costly to develop and commercialize—which is likely to be the case since software engineers and other inputs are used to generate them—or the Patent Office cannot accurately identify them from other (costly) inventions, then our computations will exaggerate the potential welfare gains from such a reform. More would have to be known about these two requirements before undertaking such a subject matter reform.

C. Reform Interaction

Most scholars and policymakers consider one policy at a time.²¹⁹ This approach allows deep scrutiny of a particular proposal, but it does not reflect the real world, where policies may interact. Especially over an extended period, it is rare to see one policy changing in isolation.²²⁰ We argue that it is vital to consider whether reforms are substitutes or complements. A pair of complementary reforms could have a strong beneficial effect even when neither policy on its own has much impact. Alternatively, a policy might be valuable when considered in isolation but offer little social benefit if another, substitute reform has already been enacted that reduces the effect of the first. One advantage of our model is the ability to vary more than one policy at once.

We illustrate the importance of evaluating policies in tandem by analyzing the interaction of (1) examination intensity and settlement restraints and (2) inter partes review at PTAB and settlement restraints. The first pair allows us to discuss interactions between a pre-grant and post-grant reform. The second pair allows us

218. With the subject matter reforms, the share of high types among applications rises by 1.3 percentage points in the scenario with a low share of abstract ideas and by 3.7 percentage points in the scenario with a high share of abstract ideas. By comparison, the simulated increase in examination intensity (combined with an increase in patent office fees) produces a 7.4 percentage point rise in the share of high types. All three start from a similar baseline of slightly less than 40% high types among applications.

219. See *supra* Section I.

220. To provide one example of this, over the past decade in patent policy, Congress has passed a major bill altering both substantive patent doctrine and procedure (the America Invents Act). For an overview, see Robert A. Armitage, *Understanding the America Invents Act and Its Implications for Patenting*, 40 AIPLA Q.J. 1, 1 (2012). Additionally, the Supreme Court has decided multiple cases that have shifted the workings of the patent system. See Lisa Larrimore Ouellette, *Supreme Court Patent Cases*, WRITTEN DESCRIPTION BLOG, <https://writtendescription.blogspot.com/p/patents-scotus.html> [<https://perma.cc/K7J6-EYCZ>] (listing U.S. Supreme Court cases and finding that the Court took thirty-three patent cases between 2012 and 2021).

to discuss interactions between two post-grant reforms. This approach to policy evaluation casts a new light on the rational ignorance debate.

Recall, the notion of “rational ignorance” favors low examination intensity and excuses the Patent Office’s many mistakes under the theory that later enforcement of commercially important patents can, and will, fix those mistakes (a court or other adjudicatory body can invalidate an erroneously granted patent).²²¹ Reviewing patents ex post may be more efficient than doing so at the Patent Office because only a small number of patents end up being commercially important and worth reviewing closely.²²² These patents are sufficiently valuable for private parties to bring litigation, and therefore, courts will have the opportunity to review the patents and, if the Patent Office has made an error, invalidate the patent.²²³

However, this theory requires that commercially valuable patents of dubious validity (1) be litigated (2) to final judgment. Thus, the optimal level of ex ante review at the Patent Office will be highly dependent on the design of ex post review, or vice versa, the optimal design of ex post review will depend very much on how ex ante examination is conducted at the Patent Office.

Critics of the rational ignorance theory contend that ex post review of patent quality is anemic, and post-grant reforms are needed to mitigate the harm caused by low levels of examination intensity.²²⁴ We performed simulations to study the interactions between examination intensity and one important type of post-grant reform—restraints on settlement. Before discussing our simulations, let us explain why a laissez-faire system of private challenges is inadequate in an environment with low examination intensity.

Private parties litigate for their own profit, and they may have incentives to act in ways that deviate from the public interest.²²⁵ A simple rational ignorance story supposes that a private party will emerge to challenge an invalid patent (as a defendant in an infringement suit, in a declaratory judgment suit, or in a quasi-judicial proceeding at the Patent Trial and Appeal Board). Unfortunately, private challenges may not be profitable, despite their social value. This is because patents, once invalidated in litigation, are invalid against the world; therefore, challengers may wait for others to bear the cost of challenges.²²⁶ In addition, even when only a

221. Lemley, *supra* note 47, at 1497.

222. *Id.*

223. *Id.* at 1509–10.

224. *E.g.*, Farrell & Merges, *supra* note 12, at 946.

225. Similar problems arise when socially harmful settlements disrupt the socially valuable role that private challenges may play as tools for regulating public procurement awards or the grant of unwarranted trademarks. *See* Robert C. Marshall, Michael J. Meurer & Jean-Francois Richard, *Curbing Agency Problems in the Procurement Process by Protest Oversight*, 25 RAND J. ECON. 297, 297 (1994); C. Scott Hemphill & Erik Hovenkamp, *Antitrust and Trademark Settlements*, 85 ANTITRUST L.J. 67 (2023), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4028144 [https://perma.cc/BYW3-TX77]. Generally, this is one version of the well-known problem of collusion by agents against the interests of a principal.

226. Many scholars have noted that invalidation of a patent may provide a benefit that spills over to benefit many firms besides the challenger. In *Blonder-Tongue v. Univ. of Ill. Found.*, the Court held that a patent claim invalidated by one party is invalid against the world. 402 U.S. 313, 350 (1971).

single firm cares about whether a patent is invalidated, that firm may not have a credible threat to challenge because the private gains from a challenge are too small. In addition, a potential challenger does not enjoy the surplus gained by consumers when a patent is invalidated, and thus socially valuable challenges may not be realized.

A second reason that ex post review may not reach many low-quality patents is that challengers can reach settlement agreements that advance their interests but subvert the public interest in clearing away low-quality patents.²²⁷ In our model, owners of low-quality patents make generous settlement offers (with probability $1-y$, as shown in Figure 3) to preempt the possibility of a challenge.

In Part III.A.1 we discussed *Actavis* and the social welfare gains that could be achieved by prohibiting negative fixed fees in licenses reached to settle patent litigation. This sort of intervention is designed to overcome the second of the two problems we just identified. The first four rows of Table 6 display simulations that help us understand the interaction between low or high examination intensity and the presence or absence of settlement restraints. The fourth row is new and the other three rows were previously displayed in Tables 1 and 4.

Because of the public good of challenges, they tend to be underprovided as the possible beneficiaries wait for someone else to bear the cost of a challenge. *See* Farrell & Merges, *supra* note 12, at 946. It is important to note that it is also possible that private challenges are overprovided because challengers do not account for the costs of litigation imposed on the patent owner and because the private gains from invalidation may exceed the social gains. Thus, no definitive statement can be made about whether private challenges are insufficient or excessive.

227. In the calibrated model, only 10% of granted patents are at risk of litigation (i.e., have sufficient private value to be challenged) and only 1.71% get litigated (for the rest, the patentee preempts the challenge through a more generous settlement offer).

Table 6. Interaction of Restraints on Settlement with Increased Examination Intensity and PTAB

Simulation	Patent Quality (share of high-type patents)	Preemptive Settlement	Litigation Rate	Change in overall welfare relative to baseline
Baseline (current policies)	56.0%	66.9%	1.7%	--
No negative fixed fee	56.0%	67.9%	2.1%	3.6%
High intensity	83.8%	56.5%	2.3%	3.0%
No negative fixed fee/High Intensity	73.2%	60.7%	2.0%	4.2%
IPR	55.8%	77.8%	4.2%	0.8%
No negative fixed fee/IPR	55.7%	77.8%	5.2%	5.1%

The examination intensity is low, $e = 0.48$, in the baseline case, and high, $e = 0.83$, in the (optimal) high intensity case. High intensity examination reduces preemptive settlement, and increases patent quality, litigation, and social welfare. Looking instead at the second row, the settlement restraint does not change examination intensity and has minimal effect of the quality of granted patents and the frequency of preemptive settlement. It also increases litigation and, despite this, social welfare.

What happens when high examination intensity and settlement restraints are combined? First, the optimal examination intensity is still relatively high, but it falls to $e = 0.74$. The social welfare gain over the baseline is 4.2%, which is larger than the gain from either high examination intensity alone or from settlement restraint alone. Notice however that the sum of the individual welfare gains from the two reforms is $3.0\% + 3.6\% = 6.6\%$, which is greater than 4.2%. Thus, the policies are substitutes to a degree.

Combining the two reforms generates approximately an 11% reduction in examination intensity relative to examination intensity that would be optimal given

no restraint on settlement. Thus, stronger ex post enforcement, in which the social harm caused by anti-competitive settlement licenses is reduced, allows for somewhat more lax ex ante monitoring of the quality of patent applications. The framework created by our integrated model allows us to study the interaction of these reforms and helps us see that our post-grant reform makes litigation “work better” and strong pre-grant intervention in the form of high examination intensity is less crucial.

We finish this Section with a discussion of the interaction between settlement restraints and another post-grant reform—inter partes review at the PTAB. Recall from our discussion in Part I.B.2 that an inter partes review allows any party to challenge patent validity in a relatively inexpensive quasi-judicial proceeding.²²⁸ The earlier article by Shankerman and Schuett simulated the impact of inter partes review, and their results are displayed in row five of Table 6.²²⁹ This simulation is similar to the simulations involving the litigation cost and accuracy trade-off reported in Table 3, but the litigation cost is even lower, and the accuracy of the inter partes review is assumed to be the same as the original Patent Office examination.²³⁰ The reform provided a substantial increase in social welfare of 0.8%.

Next, we study the interaction between settlement restraint and inter partes review. From the second row, we see that settlement restraint by itself raises social welfare by 3.6%. Interestingly, the social welfare gain when the two reforms are combined is 5.1%, which exceeds the combined benefit of the stand-alone reforms of $4.4\% = 3.6\% + 0.8\%$. Therefore, these reforms are complements. The basic intuition is that the settlement restrictions make challenges more beneficial for social welfare (they lower the royalties on low-type inventions) and that the PTAB reform makes it cheaper to challenge a patent and thereby exposes more patents to challenges. Policy entrepreneurs should emphasize this desirable interaction and advocate for these policies as a package.

IV. DISCUSSION

A. Caveats and Variations

As with any economic model, we must make various choices about how to represent the patent system; by necessity, we exclude or simplify certain institutional features and actions taken by affected parties. Our model works well, and our choices have been validated in other work.²³¹ But no doubt there are other reasonable models. We welcome and encourage other scholars to build alternative models that integrate multiple features of the patent system and calibrate the

228. See *supra* Section I.B.2.

229. Shankerman & Schuett, *supra* note 112, at 2139–41.

230. \$350,000. *Id.* at 2140.

231. *Id.* at 2134.

equilibrium outcomes to reflect the real-world behavior of the patent system.²³² Our emphasis here is not only on the choice of model but also on how it is used: to help understand the complex nature of how policy changes can affect the patent system.

To that end, we note some variations of our model that could deepen our understanding of how reforms affect the complex patent system. First, in this project we do not allow for differences in how parties behave based on characteristics such as entity size. Research on innovation finds that small firms may be cash-constrained and find it more costly than large firm to raise funds to pay for development of inventions and patenting.²³³ Policy changes that increase the cost or difficulty of obtaining or enforcing patents may present particular challenges to small firms, and it may be socially desirable to tailor reforms to firm size.

Second, the patent system affects industries differently. Scholars often note differences in innovation and patenting between high tech—software and smart phones, for instance—and the life sciences—including pharmaceuticals and biotechnology.²³⁴ It would be interesting to learn what impact reforms have on different industries and perhaps identify effective reforms that are politically feasible because they do not burden particular industries too much.

Critics of our analysis of settlement restraints may argue that the anticompetitive effect of reverse payments is limited to the pharmaceutical industry. We respond by noting the long history of price-fixing and other anticompetitive practices associated with patent licenses in a wide array of industries.²³⁵ This history suggests that other licensing techniques can be used to restrict output, but we would certainly agree that this topic deserves more study.

Third, an effective patent system discloses new technology; such disclosure may spill over to benefit other innovators and society as a whole.²³⁶ We do not address the social welfare implications of reforms that increase or decrease disclosure. Reforms that reduce the propensity of inventors of low-type inventions to patent decrease disclosure to the extent that these inventors can keep their inventions secret.²³⁷ It would be valuable to modify our model to address this issue.

232. Ufuk Akcigit & Sina Ates, *What Happened to U.S. Business Dynamism?*, 131 J. POL. ECON. 2059 (2023).

233. Gaetan de Rassenfosse & Bruno van Pottelsberghe de la Potterie, *The Role of Fees in Patent Systems*, 27 J. ECON. SURVEYS 696, 715 (2013).

234. The private value of pharmaceutical patents tends to be higher. *E.g.*, Charlotta Gronqvist, *The Private Value of Patents by Patent Characteristics*, 34 J. TECH. TRANSFER 159, 160 (2009). Patent litigation costs may be higher. Malathi Nayak, *Costs Soar for Trade Secrets, Pharma Patent Suits, Survey Finds*, BLOOMBERG NEWS (Sept. 10, 2019), <https://news.bloomberglaw.com/ip-law/costs-soar-for-trade-secrets-pharma-patent-suits-survey-finds> [<https://perma.cc/5CQG-K4T5>]. In some circumstances, patents covering products approved by the FDA are eligible for a longer patent term. 35 U.S.C. § 156; *See generally* Dan Burk & Mark Lemley, *Policy Levers in Patent Law*, 89 VA. L. REV. 1575, 1589 (2003); Galasso & Schankerman, *supra* note 69, at 317.

235. *See generally* Kovacic, Marshall & Meurer, *supra* note 151.

236. Jeanne Fromer, *Patent Disclosure*, 94 IOWA L. REV. 539, 547 (2009).

237. A related issue is the loss of disclosure when high-type inventions are not developed.

Fourth, we hope to see future scholarship that uses calibrated models to explore other concepts of patent quality and other problems in the patent system. We have focused on patent examination mistakes that result in the grant of patents on obvious inventions taking the current obviousness standard as given. Other scholars frame patent quality problems in terms of an obviousness standard that is too permissive²³⁸ or patent rights that are fuzzy or overbroad.²³⁹ These alternative notions of quality invite scholars to better assess the connection between patent reform and cumulative innovation or notice failure—topics that we have not pursued in this Article.

Fifth, and finally, our model and calibration exercise looked just at the United States. Although patents are jurisdiction-specific, meaning that they have power in only one jurisdiction,²⁴⁰ products are often sold internationally. Patentees may therefore view patenting strategy globally, both filing for patents in many countries and enforcing patents in numerous jurisdictions.²⁴¹

We do not think these variations of our model would have a major effect on our analysis. They might change the social welfare ranking of various reforms, but we doubt they would affect our fundamental contributions: (1) reforms tend to affect multiple features of the patent and innovation system, (2) some reforms are complements and others are substitutes, and (3) there is no reason to preference pre-grant reforms or post-grant reforms because both types of reforms may have effects that ripple through the system.

B. Implications for Public and Private Enforcement

The patent system is but one example of federal economic regulation that relies on case-by-case exercise of administrative discretion. Other examples include procurement, the grant of franchises (for example, a license to use radio spectrum for media services or communications), and the grant of trademarks. Some degree of ex post review of the administrative decision by private parties is permitted in each of these settings. Procurement and spectrum awards can be challenged when government officials deviate from announced award rules, and trademark validity can be challenged when firms are sued for infringement.²⁴² Much like the case of

238. Gaetan de Rassenfosse, William Griffiths, Adam Jaffe & Elizabeth Webster, *Low-Quality Patents in the Eye of the Beholder: Evidence from Multiple Examiners*, 37 J. L. ECON. & ORG. 607, 607 (2021).

239. Mark A. Lemley, *Software Patents and the Return of Functional Claiming*, 2013 WIS. L. REV. 905, 905 (2013).

240. 35 U.S.C. § 271(a).

241. E.g., Antoine Dechezlepretre, *International Patent Families*, 111 SCIENTOMETRICS 793, 793 (2017).

242. Robert C. Marshall, Michael J. Meurer & Jean-Francois Richard, *Curbing Agency Problems in the Procurement Process*, 25 RAND J. ECON. 297, 297 (1994) (procurement); Jonathan Blake, *FCC Licensing: From Comparative Hearing to Auctions*, 47 FED. COMM'NS L.J. 179, 183 (1994) (spectrum); Robert G. Bone, *Trademark Functionality Reexamined*, 7 J. LEGAL ANALYSIS 183, 231–38 (2015) (trademark). Trademarks can also be challenged in opposition and cancellation proceedings at the Patent and Trademark Office. See Melissa F. Wasserman, *What Administrative Law Can Teach the Trademark System*, 93 WASH. U. L. REV. 1511, 1524–26 (2016).

patent challenges, the potential public benefit flowing from a challenge may be derailed by a socially harmful settlement. The literature already contains models of private enforcement of procurement regulations with integrated game-theoretic equilibria,²⁴³ but not a calibration exercise. Questions about how to assure high quality procurement decisions, franchise grants, and trademark grants could be analyzed using methods that parallel those discussed in this Article.

Another direction for future research is the comparison of public to private enforcement. In the patent system, rather than relying on private ex post review of examiner decisions, we could rely on public officials to implement ex post review. If government officials had broad standing and sufficient resources, then challenges could be better aligned with the public interest in invalidating low-quality patents. Public enforcement could be implemented in several ways. It is not often noticed and commented on, but the director of the Patent and Trademark Office holds authority to order an ex parte reexamination of a patent. That power has been used on occasion in response to public outcry and resulted in patent invalidation, and it could be used more often.²⁴⁴ Alternatively, Congress could give authority and funding to the antitrust agencies to challenge patents in court. Public challengers would be unlikely to agree to socially harmful settlements, although there may be other concerns depending on precisely how public challenges were implemented—for instance, public challengers may not be adequately funded, and may not possess as much relevant information about patent validity as private challengers.

It would be interesting to revisit the rational ignorance debate in a model in which private challenges are replaced by public challenges. One might find that a system with well-funded public challenges that avoids harmful settlements might be a good complement to a system with low-intensity patent examination. Inventors of low-type inventions might be reluctant to patent if their business model depends on the assertion of low-quality patents that would attract the scrutiny of government officials who are empowered to weed out low-quality patents. The appeal of this policy approach would depend critically on whether public challengers really could efficiently identify patents that are likely to be invalid.

V. CONCLUSION

Scholars have long recognized that various policy instruments could (in theory) be deployed to improve patent quality.²⁴⁵ But this scholarship, while

243. Marshall, Meurer & Richard, *supra* note 225; Robert C. Marshall, Michael J. Meurer & Jean-Francois Richard, *Litigation Settlement and Collusion*, 109 Q.J. ECON. 213, 213 (1994).

244. Also, a species of antitrust enforcement called *Walker Process* litigation can be used by public or private parties to challenge certain invalid patents obtained by “fraud on the Patent Office.” See Christopher R. Leslie, *The Role of Consumers in Walker Process Litigation*, 13 SW. J.L. & TRADE AMS. 281, 282–83 (2008).

245. Scholars have conducted empirical research indicating that certain instruments may have a statistically significant effect on patent quality. See, e.g., John R. Allison & Starling D. Hunter, *On the Feasibility of Improving Patent Quality One Technology at a Time: The Case of Business Methods*, 21 BERKELEY TECH. L.J. 729, 738 (2006) (finding that the PTO’s “Second Pair of Eyes Review”

important and influential, is not enough for effective reform. Current scholarship is siloed (looking at only one aspect of the patent system), generally not quantified, and simplistic in a variety of other ways (for instance, failing to compare the costs and benefits of multiple proposals). Few scholars have combined data and theory to determine what policy instrument or bundle of instruments are most likely to achieve a meaningful improvement in social welfare from operation of the patent system. State of the art policy analysis should strive to accomplish both goals.

In this Article, we have presented a better approach to policy analysis. With a formal economic model, we have shown how to use an integrated equilibrium framework to assess policies' impact in a more complex setting that better reflects the real world. This methodology is a major contribution of the Article. But beyond presenting a new *way* to study patent reform, we have used our method to draw clear *conclusions* about specific policies: restraints on settlement and patentable subject matter restrictions significantly benefit patent quality, whereas changes to remedies and reducing litigation costs have minimal impact. Further, we hope to move patent scholarship and theory away from its current emphasis on pitting pre-grant policy reform against post-grant changes by emphasizing the falseness of this dichotomy—as changes to either pole of the system are not confined there but rather reverberate throughout. Finally, our project offers lessons for other areas of law, many of which suffer from challenges similar to patent policy. This Article presents a new approach to assessing patent policy, and a new approach to assessing legal reform.

program had a positive effect on patent quality); Gaétan de Rassenfosse & Adam B. Jaffe, *Are Patent Fees Effective at Weeding Out Low-Quality Patents?*, 27 J. ECON. & MGMT. STRATEGY 134, 134 (2018) (finding that increasing fees led to a reduction in low-quality patents); Bhaven N. Sampat, David C. Mowery & Arvids A. Ziedonis, *Changes in University Patent Quality After the Bayh-Dole Act: A Re-Examination*, 21 INT'L J. INDUS. ORG. 1371, 1371 (2003) (finding that the quality of academic patents declined after passage of the Bayh-Dole Act).