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Can Post-Grant Reviews Improve Patent System Design? A Twin Study of US and European Patents

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April 2006

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Abstract

This paper assesses the impact of adopting a post-grant review institution in the US patent system by comparing the "opposition careers" of European Patent Office (EPO) equivalents of litigated US patents to those of a control group of EPO patents. We demonstrate several novel methods of "twinning" US and European patents and investigate the implications of employing these different methods in our data analysis. We find that EPO equivalents of US litigated patent applications are more likely to be awarded EPO patent protection than are equivalents of unlitigated patents, and the opposition rate for EPO equivalents of US litigated patents is about three times higher than for equivalents of unlitigated patents. Patents attacked under European opposition are shown to be either revoked completely or narrowed in about 70 percent of all cases. For EPO equivalents of US litigated patents, the appeal rate against opposition outcomes is considerably higher than for control-group patents. Based on our estimates, we calculate a range of net welfare benefits that would accrue from adopting a post-grant review system. Our results provide strong evidence that the United States could benefit substantially from adopting an administrative post-grant patent review, provided that the post-grant mechanism is not too costly.

Keywords: patent system, post-grant review, opposition, litigation

JEL Classification(s): K41, K11, L10

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1 Introduction and Research Questions

The optimal design of national patent systems has been a topic of recurring interest (Kahn, 1940; Gilbert and Shapiro, 1990; Jaffe and Lerner, 2004). A well-functioning patent system is considered an effective means of spurring inventiveness, technological advancement and economic growth—but social benefits can be substantially eroded by poorly designed systems that produce, among other costly outcomes, low patent quality and high uncertainty (Hall, et al. 2004). One mechanism that has been proposed to improve the operation of patent systems is the post-grant patent quality review (The National Academies, 2004).

In the United States, the effectiveness of patent post-grant review has become particularly relevant. A number of prominent US policy panels have recommended the adoption of a post-grant review procedure to improve the US patent system. The US Federal Trade Commission (2003), the US Patent and Trademark Office (USPTO or Patent Office) (2003), and the American Intellectual Property Law Association (2004) have followed a major academic study on patent reform produced by the National Research Council (2003) and earlier work by Merges (1999) in calling for some form of effective post-grant administrative review of patent quality. The evidence on which each of these proposals build shows that: litigation is currently the only effective mechanism for challenging US patent quality *ex post*; litigation is a costly—and at times extremely costly—mechanism for testing patent validity; and patent litigation may be undersupplied, i.e. society sees fewer patent challenges than is optimal (Graham et al. 2003; Levin and Levin, 2003; Hall et al., 2004; Farrell and Merges, 2004).[1]

Among the perceived benefits flowing from a post-grant review are greater certainty, a reduction in the costs society suffers from patent litigation, an increase in society's benefits from a hastening of the pace of innovation, and a limitation on unwarranted grants of market power. Uncertainty over the validity of property rights may be particularly pernicious because unwarranted market power may deter the entry of competitive products, while blocking the development of cumulative downstream technologies. Uncertainty may also encourage "bad bets," with agents misallocating investment away from promising technologies or into technologies that turn out to be infringing *ex post*. Associated benefits may include an improvement in patent quality and the establishment of an early feedback mechanism to patent examiners as regards the quality of their work.

The simple logic supporting the adoption of an opposition system says that it offers a relatively low-cost opportunity for parties with superior knowledge to challenge the validity of patents. These parties are envisaged to be product-market competitors of the patentee, and are expected to have superior knowledge than the patent examiner concerning the novelty, obviousness, and technological- and market-development of the patented technology. It is suggested that a US opposition system would invite these “knowledgeable parties” into the process at an early stage, permitting them to disclose information about the patentability of the invention, thereby allowing for a more effective policing of the system and possibly leading to an improvement of patent quality in the system as a whole.

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[1] At time of writing, a proposal largely mirroring that of the American Intellectual Property Law Association (AIPLA) was pending as a bill before the US Congress as House Resolution 2795 titled "The Patent Reform Act of 2005," co-sponsored by Reps. Howard Berman (D.-Calif.) and Lamar Smith (R.-Texas).

Despite the positive assessment that post-grant review has received from the academic and administrative bodies, there remain open questions as to the efficacy and possible shortcomings of such an institution, particularly as it may apply in the United States. While post-grant reviews have been an integral part of the patent systems of several countries (such as Australia, PR China, Germany, India, Japan, New Zealand, Norway and Switzerland), the innovation system in the United States is unique (Mowery and Rosenberg, 1993) and thus makes the impact of a newly introduced post-grant mechanism in the US patent system difficult to predict. Reservations about the applicability of a review process in the US arise from the presumption that the opposition would increase, rather than lower, transaction costs and thus lead to a reduction in efficiency.

While the US has considerable experience with various levels of administrative patent process, including the re-examination procedure (Graham, et al., 2003) and patent interferences (Cohen and Ishii, 2005), yet another layer of process added to the patent system may raise costs without sufficient corresponding benefits. This concern is particularly relevant given criticisms over inadequate funding at the Patent Office (Jaffe and Lerner, 2004) since that agency will likely have primary responsibility for administering any such system, thereby burdening an already burdened USPTO. Moreover, costs may be imposed disproportionately among players in the innovation system. If (as we detail below) the expected cost of an opposition is significantly less than the cost of court litigation, the lower cost of challenging patent validity will likely result in challenges becoming more common, possibly imposing additional costs on patentees. These costs might substantially change the *ex ante* expected returns to patenting for inventors.

In the face of these opposing arguments, and the quickly moving policy environment, we offer an empirical study to inform the controversy. The arguments against, and in support, of the adoption of a post-grant patent review have heretofore been based, at best, on anecdotal evidence. Several fundamental questions have remained unanswered thus far: What effects will the United States adopting a post-grant review process have upon rates of patent litigation? And can society anticipate welfare gains from a (potentially) more cost-effective and rapid resolution of uncertainty concerning patent validity? Our paper uses novel data and methods to address these questions.

We employ a kind of twin study design applied in Graham et al. (2003) to US patent re-examination and European opposition. In this paper, we consider the "opposition career" of equivalents of US litigated patents at the European Patent Office (EPO). We improve upon this earlier method, however, by employing a more fully developed twinning methodology, and demonstrating three possible methods by which patents in one patent-granting jurisdiction may be matched to related patents in another jurisdiction.

Comparing outcomes in the two systems is attractive, since the EPO is today the dominant patent-granting institution in Europe. Moreover, much of the US policy debate has taken EPO opposition and appeal proceedings as a reference point, insofar as the European institution appears to be effective.[2]

The research questions considered in this paper are as follows:

[2] See Harhoff (2005) for a multivariate analysis of opposition and appeal at the EPO.

- Do twins (equivalents) of litigated US patents fare better or worse in the examination phase of the European patent system than suitably defined control-group patents? In other words, does European examination detect and exclude contested patents in the early phase of the patent granting process?

- To what extent is the European equivalent of a litigated US patent more likely to be involved in an opposition proceeding than a suitably defined control group patent?

- Are equivalents of US litigated patents more likely to be revoked or narrowed in opposition proceedings than suitably defined control group patents?

- Given our empirical findings, what are the cost/benefit implications to society of the adoption of a post-grant administrative proceeding in the United States?

In answering these questions, we focus first on the "twin relationship" or "equivalence" between European and US patents, thus identifying patents in the two jurisdictions that cover nearly identical inventions or technology disclosures. This relationship is defined by the congruence of the priority documents upon which the US and the European patent are based. We also demonstrate in this paper the broader notion of a "family relationship" between national patents. This latter relationship encompasses some degree of relationship between the two underlying technologies, but does not require that the patents be strictly "equivalents," i.e. congruence of priority documents of the respective patents. We discuss these distinctions in detail below, intending to contribute to a better understanding of international comparisons of patent systems. Clarifying and making use of the complex priority linkages between US and European patents is a novel contribution. To the best of our knowledge, no previous study has yet described, or made use of, these different relationships between national patents.

We find that EPO applications based on US-litigated patents have a *higher* grant rate at the EPO than the equivalents of non-litigated patents. Evidence suggests that owners of these patents are willing to compromise on the scope of their property rights in order to obtain a patent. In support, we find that, for the EPO twins of litigated US patents, the grant rates are higher and grant lags are longer as compared to the twins of non-litigated patents. Examination-based statistics such as the number and types of (backward) patent references do not appear to distinguish strongly between the two groups. We confirm, however, that the equivalents of litigated patents are considerably more likely to be cited by subsequent patents and to constitute prior art that is considered harmful to the novelty claim of subsequent patents.

We also demonstrate an important difference in the opposition rates of litigated equivalents as compared to non-litigated control equivalents. This crucial difference arises in the increased likelihood of opposition in litigated and "twinned" US patents: the opposition rate is approximately 20 percent, and thus about three times higher for equivalents and "relatives" of litigated patents than for control group patents. Opposition outcomes are again largely non-discriminatory if we take effective results into account. Oppositions against the equivalents of litigated patents are somewhat less successful than oppositions against control group patents. Moreover, it appears that owners of equivalents of litigated patents frequently withdraw their patents from the opposition process by letting the patent lapse, presumably in order to avoid an unfavorable opposition ruling. Owners of equivalents of US litigated patents are also more likely to file an appeal against an unfavorable opposition outcome. We account for this effect when considering the welfare impact of a future opposition system in the US.

Our results support the notion that the European system excludes equivalents of litigated US patents *due to an increased likelihood of opposition*, *and not by virtue of lower grant rates or less favorable opposition outcomes*. We argue that this finding has important policy implications in that it emphasizes the need for making opposition proceedings affordable and accessible to any party with information regarding a patent's (in)validity.

At the very core of our study is a conceptual question: to what extent would a post-grant review mechanism at the USPTO improve welfare? Two possible effects are considered. First, we consider that post-grant review would introduce a mechanism that would allow some questionable patents to be revoked or narrowed at an early stage, thus reducing the likelihood of these becoming expensive litigation cases. Second, we consider that a post-grant review system may generate benefits by revoking patents that do not now enter subsequent litigation, but without review are generating welfare losses due to excessive market power. In a high-cost litigation system such as the United States, such patents may never be challenged because obtaining a license, or finding a "work-around" to the patent, is preferred by competitors to challenging the patent's validity (even if its validity is questionable). Building on earlier work in Hall et al. (2003), but using our own estimates of opposition likelihood and outcome distributions, we present several calculations of welfare benefits that summarize the impact of post-grant reviews. Our results confirm the idea that introducing a low-cost post-grant review mechanism would allow for large welfare gains. Typical benefit-cost ratios are on the order of eight and higher according to these calculations.

The remainder of the paper is organized as follows. Section 2 offers information of the institutional background of this study, both in terms of US litigation and EPO opposition proceedings. Section 3 follows with a discussion of data issues, demonstrating our techniques for collection and analysis of US patent litigation and the construction of a control group of patents. We also document in this section patent characteristics, the opposition frequency, and outcomes of opposition proceedings for "twins" of patents litigated in the US and for the respective control group. In section 4, we use these statistics to provide an estimate of the welfare effects that could be expected from the introduction of a post-grant review system in the US. Section 5 summarizes our results and concludes.

2 Institutional Background

2.1 Litigation in the US

In the United States, patent validity may be challenged after grant in two forums: within the administrative agency (USPTO) or in the judicial branch (courts). The administrative process most often used, the *reexamination*, is *ex parte* (giving the patentee exclusive rights to communication with the decision-maker) and substantially restricts the involvement of the challenger. Graham et al. (2003) document the limited use, and usefulness, of the US reexamination proceeding, showing that only 0.3% of patents granted between 1991 and 1998 were reexamined, and that patent owners initiated more than half of these reexamination requests. A refinement of the procedure introduced in 1999, the *inter partes* reexamination, allows challengers more access, but creates such substantial disincentives to challengers that it is far less used in practice (Farrell and Merges, 2004). As a result, litigation in the US Federal courts is the predominant mechanism used to challenge the validity of a patent. Moreover, as we will make plain, it is an extremely costly mechanism for parties to access.

Procedurally, US patent litigation is a full-blown adversarial proceeding in the US federal courts. Activities include, but are not limited to investigation, preparing or answering the complaint and other documents, seeking to impose or prevent an injunction, motion practice, preparing expert witnesses, engaging in pre-trial discovery, jury selection, preparing demonstrative and human evidence, and trial. Patent suits may arise from either infringement actions by the patentee, or "declaratory judgment" suits by a challenger seeking to invalidate the owner's patent. Challengers are restricted in their ability to bring this latter type of case: in order to file such an action, there must be either an explicit threat or other action by the patentee that creates a "reasonable apprehension" on the part of the challenger that it will face an infringement suit from the patentee.

The patent owner enjoys several strong advantages in federal lawsuits. First, courts consider that a US patent is "born valid," and place the legal burden on challengers to prove patent invalidity. Second, the burden of persuasion on the challenger is the heightened "clear and convincing" standard, a burden substantially higher than the mere "preponderance of the evidence" standard that is the rule in most civil cases.[3] The costs that these burdens and barriers impose upon challengers are heightened because, in many circumstances, judges and juries have limited science and engineering training. Judicial philosophy creates added costs: Allison and Lemley (1998) suggest that during the years after the creation of the specialized patent appellate court (the Court of Appeals for the Federal Circuit, created in 1983), the rate of successful patent challenges fell from 50 percent to 33 percent.

The patentee also enjoys timing and siting advantages over challengers. In the case of an infringement lawsuit, the patent owner exerts *de facto* and *de jure* control over the timing of enforcement and litigation of the patent dispute. In infringement actions, the patentee also has first choice of geographic venue, an important consideration when one considers the heterogeneity in decision-making displayed by judges and juries in the 94 different federal district courts across the United States.[4] But even in "declaratory judgment" suits brought by challengers, the patentee exerts some control over timing. Because the competitor must have a reasonable apprehension of an infringement action, such apprehension generally comes in the form of a demand from the patentee to cease infringement.

Direct legal costs of a typical patent lawsuit are estimated to be $4 million US (AIPLA, 2003), although Farrell and Merges (2004) show that, as more money is at risk in the suit, litigation costs rise sharply—mostly driven by discretionary spending in the "discovery" phase. Another estimate puts the costs in patent litigation at $500,000 US per claim at issue, per side (Barton, 2000). While evidence suggests that about 95 percent of patent suits end in settlement (Lanjouw and Schankerman, 2001b), settlement in the shadow of litigation is nonetheless time consuming and expensive. Lanjouw and Schankerman (2001b) estimate time to settlement at 8 to 25 months, while Magrab (1993) estimates district court patent trials last 31 months. Our data analysis of patent suits litigated between 1970 and 1987 support these figures: While cases pend on average for 30.4 months, those cases settled or withdrawn last 18.7 months on average while those reaching a determination on directed, jury, or bench

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[3] Jolls, Sunstein, and Thaler quote a survey of federal judges who report that the preponderance standard is 50% while the "clear and convincing" standard requires proof to a 60-70% certainty. C. Jolls, C.R. Sunstein, and R. Thaler (1998). "A Behavioral Approach to Law and Economics," *Stanford Law Review,* May: 1530-1531.

[4] Patent lawsuits are governed by federal (United States) law, and thus trials must be originated in the federal trial-level courts, the "district courts." Appeals must be heard at the Court of Appeals at the Federal Circuit, with discretionary appeals available at the US Supreme Court.

verdict last on average 39.2 months.[5] Because surveys conducted by the AIPLA (2001) report that approximately half the estimated legal costs of litigation are incurred before the end of the discovery phase, and thus well prior to trial, litigation events, even if they end in settlement, involve substantial direct costs.

In sum, litigation in the US federal courts appears to be costly, in terms of both legal barriers and direct and indirect costs, to challengers and owners alike. These costs create a substantial disincentive to potential challengers of patents of questionable validity, particularly when the challengers are resource constrained. Farrell and Merges (2004) suggest that federal court challenges occur less frequently than is optimal due to public goods and pass through problems. Because an invalidity ruling has the character of a public good in that all the competitors of the patentee benefit, a coordination problem creates advantages to free riding, with the result that none steps forward to file suit and suffer the litigation costs. Moreover, a pass-through problem arises because accused infringers may choose to forego the costs of challenging the patent and instead pass through to consumers the costs the patentee's demand for royalty payments, without regard to the validity of the patentee's claims. Both create disincentives to challenge invalid patents, and may produce substantial welfare loss.

The opposition has been advanced as a means of improving patent system design by reducing the incidence of litigation, reducing uncertainty, and improving patent quality (Hall, et al., 2004; Farrell and Merges, 2004). Because the US post-grant review proposals are based in large part upon the experience of European nations with "patent oppositions," we turn now to a discussion of the opposition proceedings available at the European Patent Office.

2.2 Opposition at the European Patent Office

This section reviews the institutional setup of patent oppositions and appeals at the EPO. European member states can obtain patent protection by filing several national applications at the respective national patent offices or by filing one EPO patent application at the European Patent Office. The EPO provides a supra-national application and granting procedure, allowing applicants' patents to attain the same legal status as patents granted by the various national offices in the EPC signatory countries. Any third party can oppose the European patent at the European Patent Office within nine months of a patent's grant by filing an opposition against the granting decision. Opposition can be filed by any third party, but not by the proprietor of the patent, and its outcome is binding for all states in which the patent granted by the EPO has effect. If opposition is not filed within nine months after the grant, the patent's validity can only be challenged under the legal rules of the respective countries in which the patent has been validated. The EPO opposition procedure is the only centralized challenge process for European patents. Opposition may be filed on grounds listed in Art. 100 EPC. These are i) the subject matter is not patentable,[6] ii) the patent does not disclose the invention sufficiently clearly or completely so that it can be carried out by a person skilled in the art, or iii) the subject matter of the European patent extends beyond the content of the original application. A formalities officer first examines the filed opposition and can declare

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[5] These statistics are based on cases that were finalized in the same district court where the suit was filed.

[6] See EPC Art. 52-57. The invention is not patentable if a) the subject matter is not novel (Art. 52(1), 54 and 55 EPC), b) it does not involve an inventive step (Art. 52(1), 56 EPC), c) it cannot be used in an industrial application (Art. 52(1) and 57 EPC), and d) it is not regarded an invention (Art. 57 EPC) or is not patentable according to Art. 53 EPC.

it inadmissible if a formal requirement is violated. If found valid, an Opposition Division (OD) determines the outcome of the opposition case.[7] The OD is a panel consisting of three technical examiners, two of whom must have taken no part in examining the opposed patent. If the case requires legal expertise, the OD panel may be enlarged by adding a legally qualified examiner. In resolving the case, the OD will attempt to use only written proceedings (oral arguments are not required), but it may request as often as necessary written statements from the parties involved. Any of the parties involved may request, or the OD may initiate, oral proceedings.[8]. Furthermore, the OD may decide to search for new prior art material on its own initiative, thus rendering the OD both quasi-judicial (decisions) and quasi-executive (investigation).

Opposition proceedings at the EPO may have one of four possible outcomes. First, the patent may be upheld without amendments, i.e., the opposition is rejected. Second, the patent may be revoked fully, and not longer be valid as a patent.[9] Third, when amendments are proposed by the patentee, the patent may be maintained in amended form, a process that often takes the form of a negotiation between the parties, with the OD serving as mediator.[10] Finally, the opposition procedure may be closed without a directly observable outcome.[11] A "closed" opposition may occur if either (1) the opposition is withdrawn or (2) the patent is allowed to lapse for failure to pay maintenance fees. If the patent has lapsed in all EPC states in which it had effect after the grant, the opponent can request continuation of the opposition proceedings.[12] If the opponent does not pursue this right, the opposition will be closed. Thus, the interpretation of this outcome "opposition closed" is ambiguous *ex ante*.

In Section 3 of this paper, we make reasonable assumptions about these outcomes and resolve to determine their meanings empirically by examining patent renewal data. If patent renewal fees are being paid after the opposition has been closed, we assume that the opponent has withdrawn. If the payment of renewal fees ceases prior to the closing of opposition or just after the opposition has been filed, we assume that the proprietor has allowed the patent to lapse. The latter case (withdrawal by patent proprietor) appears to be about three times more likely than the former case in which the opponent withdraws. We rely on these assumptions to generate some inputs to our welfare analysis.

Another important aspect of the opposition procedure concerns the restrictions put on the opponent's ability to settle "out of court." Once an opposition is filed, the EPO can choose to pursue the case on its own, even if the opposition is withdrawn.[13] Thus, the opponent and patentholder may not be free to settle their case once the opposition is filed. This provision of the opposition likely discourages its strategic use by potential opponents interested in forcing patentholders to license their patents.

Both the patentholder(s) and the opponent(s) may appeal the outcome of the opposition procedure.[14] The appeal must be filed within two months after receipt of the decision of the

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7 See EPO (2003, Part D, Chapter VI).
8 Art. 116(1) EPC
9 For the rules covering rejecting the opposition or revoking the patent, see Art. 102(1) EPC.
10 See generally Art. 102(3) EPC.
11 See EPC Rule 60(2) (2003, Part D, Chapter VIII).
12 See EPC Rule 60(1) (2003, Part D, Chapter VIII).
13 Rule 60 EPC: "In the event of the death or legal incapacity of an opponent, the opposition proceedings may be continued by the European Patent Office of its own motion, even without the participation of the heirs or legal representatives. The same shall apply when the opposition is withdrawn."
14 Article 99ff. EPC

OD, and must be substantiated within an additional two months. Both parties can bring expert witnesses into the appeal proceedings, and there are various options for having deadlines extended. The Board of Appeal affords the final opportunity at the EPO to test the validity of the contested European patent.

The costs of opposition and appeal are typically born by each party. However, the OD may deviate from this cost allocation under certain circumstances,[15] in particular for "reasons of equity." Equity applies when "the costs are culpably incurred as a result of irresponsible or even malicious actions,"[16] which can then be charged to the party responsible. Discussions with EPO staff indicate that this option is rarely used, so that in the vast majority of cases, the costs are born by each of the parties themselves. The official fee for filing an opposition is 613€; while the filing fee for an appeal is 1,022€.

Interviews we conducted with European patent attorneys suggest, however, that the total costs to the opponent or the patentholder are much higher. Estimates of the total costs of an opposition range between 10,000€ and 25,000€ for each party.[17] Our interviews suggest that there are few opportunities for the opponent to drive up the patent owner's costs, for two reasons: i) attorney fees are regulated in most European countries, including Germany, where many patent lawyers who have the required EPO registration reside; and ii) the institution of "discovery," a main cause of the high costs of US litigation, does not exist in the EPO opposition system.[18] Our interviews also revealed that apportionment rules under the EPC should also serve to discourage attempts to drive up the other party's costs.[19] In sum, the European opposition has three important advantages in comparison to US litigation: it is considerably less costly, opportunities for strategic manipulation of an adversary's costs are more restricted, and limitations on settlement make opposition less attractive as an instrument to extort payments from the patent holder.

3 Data Issues and Empirical Results

3.1 Identification of Litigated US Patents - Sampling and Validation

Information on the litigation history of United States patents has been difficult to collect. This difficulty is even more vexing when one considers the importance of patent litigation in the United States, the strategic opportunities it presents, and the ramifications it has for competition and industrial organization more generally. Lack of data has substantially reduced the ability of researchers to study empirically questions related to patent litigation, and to the testing of patent validity more generally (Hall et al., 2004). While there are notable

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15 Art. 104 EPC

16 EPO (2003, Part D, Chapter IX, 1.4)

17 Mewburn Ellis LLP (http://www.mewburn.com/meepopf.htm, June 30th, 2004) give ranges between $5,000 and $15,000 to prepare and file a Notice of Opposition for standard cases, and between $8,000 and $30,000 for the subsequent correspondence and oral proceeding.

18 Markus Herzog, a Partner at Weickmann & Weickmann, Munich, estimates the cost for each side to be €7,000 for the opposition and €10,000 for the appeal stage if the parties employ patent attorneys at the EPO's location (i.e., without cost of travel). He also notes that the parties have virtually no way of driving up their adversary's costs. In an updated interview March 2005, he put the costs of opposition in a range of €10,000 - €15,000. (Conversations on Oct. 17, 2001 and March 10, 2005).

19 EPC Art. 104.

exceptions in the literature (Lanjouw and Schankerman, 2001; 2001b; Somaya 2003), studies have nevertheless been few given the importance of the subject matter.

Our study makes use of litigation data collected from the Litalert database that includes patent suits reported to the United States Patent and Trademark Office by the US District Courts since 1973. We supplement these data with information supplied to the Federal Judicial Center by US courts made available through the Inter-University Consortium for Political and Social Research. Our data contain over 32,000 individual litigation records and match to over 25,500 US patents issued 1963-2003. A thorough discussion of our validation of these data against earlier studies is included in Appendix A.

As discussed in the appendix, our Litalert™ data appear to be a comprehensive sample of patents litigated in the United States 1963-2003, when one allows for the recorded underreporting of litigation events in the early years and right-side censoring due to patent cases having long lags when compared to patent application dates. Our data correspond reasonably well to the data used in earlier studies (Lanjouw and Schankerman, 2001; Somaya, 2003) and indeed appear more comprehensive in several respects. Because our data more accurately reflect patents litigated in the US during the 1990s-present, they are a more meaningful sample from which to draw conclusions about the effects of adopting a post-grant patent review in the United States.

3.2 Creating a Matched Sample of US Patents

This study compares European "equivalents" of litigated US patents (see section 3.3 below) with European “equivalents” of non-litigated (control group) US patents. While it is typical in empirical patent studies to create a matched sample on application date and technology class, there are assignee identity characteristics in our US litigated patent sample that make a simple application year-technology class strategy inappropriate. Consistent with Lanjouw and Schankerman (2001), our litigated patents are much more likely than the typical patent to be assigned to a domestic (US) organization, and much less likely to be assigned to a foreign (non-US) organization. For all patents, the likelihoods that a patent will be unassigned, assigned to a US organization, or assigned to a non-US organization are 18%, 47% and 33% respectively, while for our litigated sample the likelihoods are 25%, 62%, and 11%, respectively. To avoid selection problems arising from assignee characteristics, we matched our sample on four bases: patent application year, 4-digit IPC technology class, nation of first inventor origin, and USPTO assignee code (1-7, as applied by the agency).[20] Using this technique we were able to match in excess of 98% of our US litigated patents. For those patents we could not match using this method, we reverted to the simple application year-technology class method used in previous research (Graham et al. 2003).

The advantage of using a sample of matching (presumably) non-litigated US patents[21] and obtaining data on the respective equivalents is that this approach enables us to study differences in grant rates and in other procedural variables, such as time to grant, between equivalents of litigated and non-litigated US patents. In particular, we can determine whether

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[20] These assignee classifications are described in Hall, Jaffe and Trajtenberg (2001).

[21] The sample was generated from all US patents not in our litigated sample. Thus, we expect at most that 1% of our control group patents were litigated (following Lanjouw and Schankerman, 2001), and more likely less.

the owners of US litigated patents are less likely to be granted European patents than owners of US control group patents.

3.3 Identification of Patent Equivalents and Patent Families

We extend earlier work by Graham et al. (2003) in identifying foreign related patents of our sample of US-granted patents. This earlier study exploited a relationship between US and European (EPO) patents that can be best described as "family membership."[22] Because the differences between "equivalent" and "family" patents in this context are important, we consider them in more detail.

Strictly speaking, patents are highly unlikely to ever be *equivalent* since the national laws determining the legal rights bestowed on patent owners will differ even if patents have exactly the same wording. An applicant seeking patent protection in various jurisdictions is faced with different patent laws and procedural practices. If a US patent applicant seeks to obtain a patent at the European Patent Office, she typically will use a somewhat modified version of the US application and file this document within the priority year at the EPO or WIPO (World Intellectual Property Organization). If the applicant files a PCT (Patent Cooperation Treaty) application, the EPO will typically be the target office for US or international applicants. In both the US and EPO system, a patent may claim priority documents other than the patent's own application. These priority documents are important, having ramifications for "priority of invention" and also because strict rules govern the elapsed time during which applicants may secure protections in other patenting jurisdictions around the globe.

Patent practitioners use at least three different classifications to characterize linkages between patent documents in different jurisdictions. These linkages are based upon the priority documents to which patents in different jurisdictions claim benefit. When matching a US patent to a non-US patent, we will follow convention and refer to the non-US patent matched under these different methods as an (1) equivalent, a (2) family patent, or an (3) extended family patent. Figure 1 shows an example of our approach.[23]

[Figure 1 about here]

As our most conservative identification method, we will refer to patents as "equivalents" if they share exactly the same set of priority documents. Given a group of patents that share some priority documents (D1-D5 in Figure 1), only those that share *exactly the same set of priority documents* would be considered "equivalents" for our analysis. In Figure 1, only two patent documents (D2 and D3) are equivalents because they are based on exactly the same set of priority documents (P1 and P2). None of the other documents is equivalent with any other in the set.[24] In our study, D2 could be a US patent document while D3 could be an EPO

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[22] We referred to these patents in the earlier paper as equivalents, but we use a different notation here which is more consistent with patent attorney practice.

[23] Our definitions and treatment follow the discussion of patent family relationships provided in http://www.european-patent-office.org/news/epidosnews/source/epd_4_00/14_4_00_e.htm. See also http://www.piug.org/patfam.html for a discussion of alternative approaches.

[24] We detail below that our matching the US litigated patents to their European (EPO) equivalents produce a reasonably limited share of patent counterparts – approximately 18%. This figure differs substantially from the findings in Graham et al. (2003) where we used an extended definition of family relationship among

patent document. Since they refer to the same set of priorities, we can identify these two documents D2 and D3 as equivalents.

The identification methods used to collect a non-US "family" patent and "extended family" patent of a US document are less conservative than for "equivalents" in that we relax the requirement that exactly the same set of priority documents are required to produce a match. In the case of what we call a "family" patent of a US document, patents are matched when they have *at least one priority document* in common. In Figure 1, documents D1, D2 and D3 form a patent "family," since they have at least one priority in common (P1), while D2, D3 and D4 also form a "family," as they have P2 in common. Documents D4 and D5 also form a "family" based on the common priority P3.

In the case of an "extended family" patent of a US document, matching is even less conservative: members of an extended family are defined as the set of documents *linked either directly or indirectly through common priority documents*. In Figure 1, all the documents D1, D2, D3, D4 and D5 belong to the same "extended family" —they are linked directly and indirectly through the common priorities P1, P2 and P3. This definition is the least conservative because documents such as D5 and D3 (Figure 1) do not have a priority document in common, but they are linked by document D4 and priority P2.

Information on European patents related to our given sets of US patents was obtained from the ESPACE database. ESPACE lists "equivalent" and "family" patents as defined above. The latter definition is also used in INPADOC data (which are incorporated into ESPACE). For our analysis using extended patent families, we rely upon the OECD Triadic Patent database to provide us with the non-US "extended family" patents for our US documents. The Triadic database is restricted to patent families that have family documents in all three major patent offices (EPO, JPO, and USPTO). Obtaining the members of the "extended family" without this geographic restriction requires data on the priorities of US and EP patents that are difficult to obtain.

A summary of the results of our matching using the three different methods is presented in Table 1. While we identified in the previous section 25,482 litigated US patents, only patents with US filing dates after 1976 can have an EP equivalent because the European Patent Convention was not in force prior. This date limitation leaves us with 18,033 litigated US utility patents and 18,033 matched US patents (obtained through stratified random sampling with replacement). Due to replacement, our group of matched patents contains a small number of multiples.[25]

[Table 1 about here]

For the 18,033 granted and litigated US patents, we were able to identify 3,424 equivalent EP applications. In some cases, a US patent has several equivalents—the 3,424 EP patent applications are related to 3,342 non-identical US patents. For the 18,033 granted and matched (control group) US patents, we identified 3,328 equivalent EP applications (on 3,206 US patents). Thus, the likelihood of finding one or more equivalents is only slightly higher for the presumably more valuable group of litigated patents. For both groups, the probability of

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patents. As we show later in this paper, although the definitions are quite different, very similar results with respect to the opposition propensity emerge.

[25] There are 104 duplicates, 2 triplicates and 2 quadruples.

finding an equivalent is low (19.0 and 18.5 percent for litigated and control group patents, respectively).

Generating a control group of US patents allows us to extend our analysis beyond the workings of the opposition procedure. In particular, we can employ our controls to observe whether litigated and non-litigated (control) patents have the same likelihood of having an EPO equivalent (or related family members).[26] But doing so comes at some hazard: it is important to note that while we have matched the US patent pairs with EP patent applications, we do not necessarily have corresponding EP application pairs (or pairs of granted patents) for all US pairs.

These differences are important for the interpretation of our descriptive statistics. For the purpose of our comparisons, we have to distinguish between four types of equivalent EP patent applications: 1) EP patent applications that are equivalents to US litigated patents, but without a paired EP patent application that is equivalent to the (paired) US non-litigated patent; 2) applications equivalent to US litigated patents for which an equivalent to the (paired) US non-litigated patent exists; 3) the group of applications being equivalent to US control group patents and having matching EP observations in group 2); 4) a group of EP applications equivalent to US control group patents, but without a matching EP equivalent to the paired litigated patent. It is clear that groups 2) and 3) allow for the most reliable controlled comparison, but the matched pairs in this comparison are the result of consecutive selection effects. In particular, we expect that patents in groups 2) and 3) are more valuable than other patents because the likelihood of being in this sample is conditional on the existences of an equivalent for the litigated *and* the existence of an equivalent of the control group patent. This probability may be high in technical fields in which patents are particularly valuable or have global reach, and so create incentives patent applicants to file both in the US and in Europe.

Table 1 also lists the numbers of EPO documents that are not equivalents, but are related to our US litigated patents and the patents in the control group. Selecting all "relatives" of our US patents, we identify 7,728 EPO applications that are related to our 18,033 litigated patents, and 7,045 EPO "relatives" of the 18,033 non-litigated patents comprising our control group. The ratio of identified EPO applications to US patent documents is higher for the litigated US patents (42.9%)[27] than for the control group patents (39.1%). While this difference suggests that owners of more valuable patents (which are also more likely to be litigated) are seeking protection in Europe more often, it may simply reflect the fact that owners are filing more applications in support of a core invention than for less valuable patents.

Because our sample of litigated patents (N=18,033) differs in important characteristics from the population of all granted US patents, we also explored the hypothesis that our litigated-and-equivalent sub-sample (N=3,342) differs from the entire sample of litigated patents. We find that there are only small (yet significant) differences in the distribution of primary

[26] Jensen et al. (2006) use the OECD Triad Patent Family Database to study examination outcomes at the USPTO, JPO and EPO. Our approach makes some of the selection effects transparent that they do not consider.

[27] This figure is consistent with the Graham et al. (2003) findings for EPO matches to US patents in pharmaceuticals, biotechnologies, semiconductors, and computers.

international-patent classes.[28] In terms of assignee identity, the likelihoods that a litigated and equivalent patent will be unassigned, assigned to a US organization, or assigned to a non-US organization are 15%, 62% and 21% respectively. These shares more closely represent the overall population of granted patents in terms of unassigned and foreign organization-assigned patents than does the litigated sample, although the share of US organization-assigned patents is substantially higher, in line with the litigated sample.[29]

3.4 Examination and Opposition Process Outcomes for EP Relatives of US Litigated and US Control Group Patents

Table 2 presents a first set of comparisons between EPO patent applications. The four columns represent the different groups of "equivalent" applications (as defined in section 3.3). In the subsequent discussion, we first focus on the comparison of columns 2 and 3. The comparison of unpaired equivalents in groups 1 and 4 confirms our results, but due to differential selection effects, the statistics differ between group 1 and 2, and group 3 and 4, respectively.

[Table 2 about here]

We first study the examination outcomes in Europe. We find that the EP grant rate is considerably *higher* for the equivalents of litigated patents than for twins of the control groups. In our paired comparison, 80.3 percent of equivalents of litigated patents achieve a patent grant, 15 percent are withdrawn or refused, and 4.8 percent are still pending (column 3). The grant rate for equivalents of non-litigated US patents is 67.9 percent, 27.4 percent are withdrawn or refused, and 4.7 percent are still pending. In the unpaired comparison between columns 1 and 4, the grant rates are 68.9 and 59.9 percent, but about 9 percent of examination cases are still pending.

This finding confirms that the outcomes of patent examination cannot be taken as a simple indicator of patent quality. The decision to pursue an application is the result of complex tradeoffs between patent scope and patent value. For an economically important invention, a patent holder may be willing to accept even a highly restricted patent (low scope) while for an economically unimportant one, the patent holder may simply withdraw the application.[30] Applicants with valuable patents can be expected to put more effort into securing a patent grant (even if the claims are narrowed by the examiner during the give-and-take of the examination process). For our control group, the grant of a narrowed version may no longer be economically attractive and thus applicants may be more willing to abandon the prosecution instead of expending more resources in the patent-seeking process.

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[28] Distributions for primary international classes A,B,C,D,E,F,G, and H are as follows, for Litigated sample and (Litigated & Equivalent sub-sample), in percents: 24.3(23.5); 22.2(21.3); 6.7(8.5); 1.0(1.1); 5.1(3.0); 7.8(6.4); 19.5(21.4); 13.4(14.8).

[29] In the overall population (and litigated sample), for unassigned, assigned to a US organization, and assigned to a non-US organization, respectively: 18%(25%); 47%(62%); and 33%(11%).

[30] Discussions with German patent attorneys confirm this view. "Examiners may be uninformed, or too generous. Patent applicants can make it very difficult for examiners to say 'No.' I have seen incidents in which an examiner wants to refuse an application, but the applicant arranges a meeting with attorneys and technical experts – and the examiner is put under pressure and in the end allows the patent. The patent may not be what the applicant wanted, but the applicant gets a patent nevertheless." Interview with Dr. Michael Wallinger, March 8, 2005.

Table 2 also contains information about a number of application characteristics. When compared to the equivalents of control-group patents, equivalents of litigated patents typically contain more claims and the search reports associated with these applications subsequently have a larger number of references to earlier patents. The search reports for equivalents of litigated patents also indicate a somewhat larger share of critical references of the X or Y type than for equivalents of control group patents. These lettered designations indicate that the search examiner at the EPO has found more damaging state of the art (backward citations). However, the differences are small and not always significant.

When we consider the number of citations received by our equivalents, it is clear that equivalents of litigated patents (in columns 1 and 2) have about twice the number of citations than equivalents of non-litigated patents (in columns 3 and 4). Both comparisons yield highly significant test results. Moreover, the classification in the citing search reports indicates that equivalents of litigated patents are likely to establish higher hurdles for subsequent applications than equivalents of control group patents do. The share of X citations is significantly higher in column 2 than in column 3. The other comparisons (columns 1 and 4 for share of X citations, and both comparisons for the share of Y citations) do not indicate significant differences.

We continue our exploratory analysis by restricting attention to patent applications that yielded an actual patent grant. Table 3 mimics the structure of Table 2 in that the inner columns 2 and 3 allow again for a paired comparison while statistics for the unpaired cases are displayed in the outer columns 1 and 4. We now change our focus to the likelihood of opposition and on opposition outcomes.

[Table 3 about here]

Given the higher grant rate for equivalents of litigated US patents, it is not surprising that the number of observations in column 1 is considerably larger than the size of the corresponding group in column 4. Our first result is that the time to grant (or grant lag) is significantly higher for the equivalents of litigated US patents. However, in the most reliable paired comparison, the difference is small (0.14 years).

The most pronounced difference can be found in the opposition frequency statistic. Equivalents of litigated patents are about three times more likely than equivalents of non-litigated patents to be challenged under opposition. From our descriptive statistics, we cannot determine at this point whether the increased attack rate is due to the (presumed) higher value of patents represented in columns 1 and 2, or to the perception on the part of the challenger(s) that the targeted patent may be a particularly easy one to challenge (i.e., it promises a high success rate).

Our outcome statistics help us to illuminate this question to some degree. Note first that the share of pending opposition cases is higher for the equivalents of litigated patents. Taking columns 2 and 3 as the basis of our comparison, we note that the grant lag did not differ substantially, and yet the construction of our pairs should adequately control for application year effects. Hence, the opposition proceedings for the patents described in column 2 appear to consume more time than for those described in column 3. Again, this finding is likely the result of endogenous effort allocation—parties will fight harder to maintain (or destroy)

particularly valuable patent rights. However, we can show that neglecting pending cases is harmless.[31]

Considering the distribution of outcomes, we find one unexpected result in Table 3. A surprisingly large number of cases among opposed equivalents of litigated US patents end up with the opposition being closed, i.e., abandoned (14.7 percent in column 1 and 13.0 percent in column 2). The respective comparison figures are significantly smaller, as is the share of this outcome in the population of opposition cases (5.3 percent, see Hall and Harhoff 2004, Table 2). Between 22.6 and 24.4 percent of litigation cases yield a revocation of the equivalent EPO patent, while the revocation rate is between 39.5 and 27.6 percent for control group cases. A naive interpretation of these data would imply that the revocation rate is significantly lower for the litigation group of equivalents. However, these "closed" cases may include those in which either the opponent withdrew from the proceedings or the owner withdrew (e.g., by no longer paying renewal fees).

In order to explore this hypothesis, we investigate these cases in more detail and assigned each "closed" case to either a "rejection" (in cases where the opponent withdrew) or to "revocations" (when the patent holder allowed the patent to lapse). We assign a patent to a "patent revoked or lapsed" outcome whenever we find no evidence that an equivalent was validated by a national office in any of the designated states. Conversely, we assign the outcome “opposition rejected or withdrawn” if the patent was validated and renewal fees were paid at any of the national offices. The results of an analysis of these reclassifications are shown in Table 3 as “opposition outcomes (consolidated).”

Analysis after reclassification demonstrates that the revocation rates are now roughly equal between the equivalents of the litigated and control sample. Nevertheless, more cases are amended for the equivalents of litigated patents than for those of matched patents in column 2 and 3, and the litigation group has a somewhat lower revocation rate. One possible explanation of this finding is that patent-holders are seeking to maintain their "valuable" patents, even in a more narrowed form. One explanation for the increased share of “opposition closed” outcomes for matches to litigated patents is that patent holders seek to avoid an official invalidation by the EPO and prefer to drop the matter by instead allowing the patent right to lapse.

The hypothesis that owners of litigated US patents exert considerable effort to keep their IP rights in force is also demonstrated by the difference in appeal rates. In 52.0 percent of all opposition cases targeting EP equivalents of litigated US patents (weighted average of 50.7 and 55.6 percent in columns 1 and 2), the patent owner appeals the outcome. We find that only one third of all cases concerning equivalents of matched US patents enter an appeal phase (42.9 percent in column 3 and 26.9 percent in column 4, yielding a weighted rate of 32.5 percent).

Neglecting the differences between paired and unpaired EP equivalents, we present in Figure 2 a graphical depiction of the differences between opposition rates for the EP equivalents of US litigated patents and equivalents for the control group. Cases pending in examination were excluded. While the overall opposition rate for the matches to US litigated patents is declining over time, the trend demonstrates that the opposition rate for equivalents of US litigated

[31] When we restrict the data to include application years prior to 1990, the share of pending cases is almost zero, but the distribution of outcomes remains stable.

patents is substantially higher (on the order of 3:1) than that of the equivalents of the control sample throughout 1981-2001.

[Figure 2 about here]

3.5 Examination and Opposition Process Outcomes for EP Relatives of US Litigated Patents and for EP Control Group Patents

An alternative to matching US litigated patents with non-litigated US patents would be to create a match between equivalents of US litigated patents and suitably defined EPO patents. The advantage of this approach is that it conditions on characteristics of the European relatives of the US litigated patents. Hence, the differential selection effects that make the statistics in Table 3 and Table 2 hard to interpret would not disturb the comparison.

To proceed along these lines, we maintained all 7,728 unique relatives (3,424 equivalents, 1,248 family members and 3,138 members of the extended family) of our 18,033 US litigated patents. Using the population of EPO applications, we performed a random sampling of control patents (with replacement) using priority year, priority country, technology field and grant status as conditioning variables. Due to some missing data, we can include only 3,386 equivalents of US litigated patents and their EP control group (instead of 3,424), and 4,286 non-equivalent family members of US litigated patents and their EP control group (instead of 4,304) in the comparison. The descriptive statistics are summarized in Table 4.

[Table 4 about here]

This comparison provides a robustness check for the earlier results. The main insights from the comparison of the data in Table 3 and Table 2 are confirmed. EPO applications related to litigated patents are broader in scope (have more claims), contain more references to earlier patents, and receive more citations from subsequent patents than EP applications matched using the procedure described above.

More importantly, these patents take longer to achieve a patent grant. They have an opposition rate that is about three times higher than in the control group, and the share of opposition cases effectively leading to revocation is slightly lower than for control group patents. These statistics support our hypothesis that holders of US patents litigated in the US may be exerting more effort to win a patent at the EPO. Furthermore, opponents are attacking these patents in opposition even in the face of somewhat reduced chances of success *ex ante*. Finally, we confirm that the appeal rate for EP "incarnations" of US litigated patents is significantly higher than for control group patents.[32] Thus, our main results hold irrespective of the chosen control group design.

The differences in opposition rates, outcomes, and appeal rates between equivalents and non-equivalent family members of litigated US patents point to what may be strategic applicant behavior. Applicants perceiving high value in their patents may be tempted to complement the equivalent application with additional, auxiliary applications (non-equivalent family members). We showed in Table 1 that the families of litigated US patents are larger than

[32] We also performed a comparison of non-equivalent family members of the US litigated and the US control group patents. We consider that test more difficult to interpret as we lose most of the matching structure. However, leaving this caveat aside, we obtain results that are very close to the ones summarized in Table 5.

those of control group patents. These family patents may not be as valuable as the sister litigated patent (they have lower citations and grant rates), but they are attacked more often and they appear to be more prone to be revoked, as is borne out in the data (see Table 5). Moreover, appeal rates confirm this view: Among "equivalents" (which are our statistics suggest are more valuable), the appeal rate is higher than for the non-equivalent family members of litigated US patents.

As the results in Tables 2, 3, and 4 show, litigated patents (and their European equivalents and family members) are characterized by higher citation counts than the control group patents. Theoretical arguments predict that valuable patents are more likely to be attacked in opposition (Harhoff and Reitzig, 2004). Furthermore, patent value and the likelihood of infringement are directly proportional, and therefore valuable patents can be expected to be involved in litigation cases with increased frequency. We are interested in determining whether the opposition process is (principally) triggered by higher patent value, or whether these target patents are (also) selected because opponents identify them as likely candidates for revocation. To clarify the difference, assume for a moment that settlement does not occur in opposition proceedings.[33] Assume that an opponent will file an opposition if the expected benefit exceeds the cost of doing so. Let p be the probability of revocation (we neglect amendments for the sake of brevity), V the gain from revocation to the opponent, and c the cost of opposition. If $pV > c$, then the rival will file an opposition.

We consider that patents may be opposed either because the likelihood of revocation is comparatively high, or because the value of the revocation is high to the opponent.[34] Suppose that we transform this inequality by taking logarithms and add a normally-distributed error term to obtain $ln\ p + ln\ V - ln\ c > \varepsilon$. We estimate this equation using a set of covariates used in Harhoff (2005) to control for patent value and costs. We actually interpret all regressors used by Harhoff (2005) as value or cost indicators (some may be related more to p than V) and add dummy variables to identify EPO patents with equivalents or family members that were litigated in the United States. The results of this exercise are shown in Table 5.

[Table 5 about here]

The population for this analysis is defined as all EPO patent grants with US priority and grant years from 1980 (when the first EPO-examined patents were granted) through 2000, inclusive. We restrict ourselves to US-priority patents in order to avoid complications arising from selection effects. We restrict the actual sample further, since we lack covariates for our full sample of patent grants. We obtain a sample of 122,568 patents, of which 1,443 are equivalents to US litigated patens, and 1,126 are non-equivalent family members of US litigated patents.

In column (1), we simply report the incremental opposition incidence of these two groups relative to the reference group (i.e., EPO grants not related to US litigated patents). In the reference group, the opposition rate is 5.98 percent. For the equivalents of litigated patents, it is 18.09 percent, and for non-equivalent patent family members, it is 22.74 percent. While these figures come from a subset of the patents analyzed in Table 5, they are nevertheless

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[33] Harhoff and Reitzig (2004, fn 24) report interview evidence that cases settled privately during the opposition period at the EPO constitute only 10 to 25 percent of patents that are actually opposed. This suggests that the selection of cases is mostly decided based on the potential opponent's participation constraint.

[34] We do not consider whether this value is generated by the latent promise of the technology, or whether the opponent holds asymmetric stakes (Somaya, 2003).

quite close to the estimates presented above for the more complete samples. In column (2) we present the marginal effects of the litigation dummy variables from a probit regression that contains (a) grant year and (b) technical field dummy variables. The coefficients are within one standard error of the population mean effects tabulated in column (1). When we extend the specification using a broad set of variables related to patent value in column (3), we find that some of the variation is accounted for by these variables. Controlling for the value correlates, we find that equivalents of US litigated patents are 6.92 percent more likely than other patents to be involved in opposition, and non-equivalent EPO family members are 9.02 percent more likely to face opposition. An important caveat is in order, however: it is likely that the litigation status of the patents captures unobserved value components even when we control for observable value correlates (such as the variables listed in the note to Table 6).

4 Empirical Implications

Our findings strongly suggest that US litigated patents are more likely than are "average" patents to be candidates for post-grant review in jurisdictions where that review is available. We point out that the comparison is conservative because the European examination procedures are less permissive than those in the US patent system—upwards of 20 per cent of US litigated patents, and 30 per cent of non-litigated patents, are never awarded patent protection in Europe. Thus, we expect the twin of a US litigated patent to have been screened more carefully than the corresponding US patent. Our estimates of post-grant review likelihood are thus bound to be conservative, but a detailed assessment of the breadth and private value of these patents is currently beyond the scope of our paper. We expect the actual post-grant review frequency in the US to be higher than in Europe as long as the respective costs are similar.

The social welfare implications associated with our findings are substantial. Even if we disregard the fact that EPO examination is resulting in a more precise delineation of patent rights (due to more strenuous examination), our findings show that roughly 19 to 24 percent (see Table 4) of the patents litigated in the US are likely candidates for post-grant review, and that about one third of these would be revoked outright. The effective revocation rate is likely to be even higher: Conversations with German patent attorneys who both prosecute patents and contest oppositions suggest that approximately 50 percent of "partial revocations" result in a patent that is substantially damaged.[35] It thus appears that the mean impact of a "partial revocation" is likely to reduce the enforceability of the patent considerably. We suggest that the effect of the “partial revocation” would also lower the likelihood that such a patent could become a credible threat and would be used to initiate an infringement suit or to force competitors into socially inefficient “inventing-around” strategies.

Our results allow us to generate some welfare calculations estimating the benefit that would flow to the United States from adopting a "post-grant review" procedure. While this exercise can by definition produce at best an estimate, our calculation is based on underlying characteristics of the patent and that it is inherently conservative.

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[35] The comments of one expert are representative of these opinions: "If 100 patents are opposed and all are adjudged as 'partially revoked,' approximately 25 will be left largely undamaged, 50 will have their validity substantially affected, and for 25 the result will be deadly." Interview with Dr. Michael Wallinger, March 8, 2005.

We propose to compute the welfare impact as follows. On the benefit side, we expect a reduction in the number of cases that will ultimately be litigated, because the post-grant review will act in many circumstances as a substitute for litigation. Hence, the litigation costs for these patents will be saved. Second, even if a patent is *not* litigated in the current US system, under a new low-cost review system, some patents will be opposed and again (as we show for the group of twins of non-litigated US patents), about one third of these non-litigated patents will be revoked. We will assume that, absent post-grant review, allowing such patents to remain in force causes welfare losses, the result of excessive market power being allocated to the patent holder. Naturally, the cost of post-grant review must be taken into account as well.

Our first term, estimating the benefit from saved litigation expenses, can be written as follows. Let P be the number of patents granted in a given year and p_L be the probability of litigation in the current system. The probability of post-grant review for litigated patents is denoted $p_{O,L}$, and $p_{R,L}$ is the probability of revocation of litigated patents in post-grant review. We will assume that 50 percent of the patents that are partially revoked are the equivalent of "revoked" patents, consistent with the testimony of experts in this field. $p_{PR,L}$ is the probability of partial revocation in post-grant review for litigated patents. The average social cost of litigation is denoted S_L.

$$W_1 = p_L \cdot P \cdot p_{O,L} \cdot (p_{R,L} + 0.5 p_{PR,L}) \cdot S_L \tag{1.1}$$

The computation of the welfare gain from revoking or partially revoking patents that bestow excessive market power on patent holders can be written as

$$W_2 = (1 - p_L) \cdot P \cdot p_{O,NL} \cdot (p_{R,NL} + 0.5 p_{PR,NL}) \cdot S_{NL} \tag{1.2}$$

where $p_{O,,NL}$ is the probability of post-grant review for non-litigated patents, $p_{R,NL}$ is the probability of revocation in post-grant review for non-litigated patents, $p_{PR,NL}$ is the probability of partial revocation in post-grant review for non-litigated patents, and S_{NL} is the social cost originating from patent market power awarded in error.

Finally, the cost of the post-grant review system can be written as

$$C = p_L \cdot P \cdot p_{O,L} \cdot (C_O + (p_{A,L} \cdot C_A)) + (1 - p_L) \cdot P \cdot p_{O,NL} \cdot (C_O + (p_{A,NL} \cdot C_A)) \tag{1.3}$$

where $p_{A,L}$ is the probability of appeal in post-grant review for litigated patents (conditional on post-grant review), $p_{A,NL}$ is the probability of appeal in post-grant review for non-litigated patents (conditional on post-grant review), C_O is the average cost of post-grant review, and C_A denotes the average cost of appeal following a post-grant review.

These calculations of the potential societal savings from reducing litigation (1.1), the societal savings from reducing the maintenance of unwarranted patent monopolies (1.2), and the societal costs of running a post-grant review process (1.3) allow us to arrive at more precise estimates than have been available to date. We tabulate the results of our calculations in Table 6. All columns take the opposition and outcome frequencies from our findings presented in Table 5 (equivalents, outcome after reassignment of closings, weighted averages of columns (1) and (2) and columns (3) and (4)).

[Table 6 about here]

In our benchmark scenario 1, the estimate of the probability of litigation is taken from Allison et al. (2003) as 32 suits per 1000 patents. Alternatively, we use the more conservative probability given by Lanjouw and Schankerman (2001) as 10.1 cases per 1000 in scenario 2. For the cost of litigation, we use the value of $4 million as reported by the AIPLA (2003). Because we are aware that very few cases reach the verdict stage, we also use an alternative (and conservative) assumption, allowing litigation costs to be as low as $2 million. As we outline below, however, the litigation cost assumption is not the primary driver of the overall cost-benefit ratios.

Our calculations require us to assess the social costs of non-litigated, but objectively invalid, patents. Hall et al. (2003) estimate a conservative average welfare loss of $2 million for cases in which the patent is not litigated, but questionable. They employ value estimates from Harhoff, Scherer and Vopel (2003) of 4.4 million DM (in 1977) for patents that survived opposition. Allowing for annual 4 percent growth, we assume such opposed patents will be worth (in 2006 terms) 3.5 million Euros. We assume that patents which could have been, but were not, challenged and revoked in opposition will impose the same welfare loss from monopoly power, which, with linear demand and constant marginal costs, is equal to one half of the monopoly rents.[36] In order to explore the sensitivity of our results we assume three different states of the world, with welfare losses alternatively of $4, $2, and $1 million. We use our estimated $4 million figure in scenarios 1, 2, 5, and 8, a conservative $2 million figure in scenarios 3, 6, and 9, and in scenarios 4, 7, and 10 we employ a very conservative estimate of $1 million.

In order to obtain our estimates, we must also make an assumption regarding the cost of post-grant review. Given that the likelihood of post-grant review and of appeal is likely to be a function of costs (assuming that the demand for post-grant review is elastic with respect to price), it would be unwise to deviate far from the actual cost situation at the EPO. Somewhat conservatively, we estimate the total opportunity cost of post-grant review to be $100,000 US, an amount greater than actual EPO costs. For the appeal, we use this same cost figure, an assumption that appears justified given the experience at the EPO (see footnote 10).

The calculations in scenarios 1-4 are based on these reasonable estimates of the costs to parties of engaging in the post-grant review. While our estimates of these costs are predicated upon what we consider the best available proxy measure—the actual cost of European opposition proceedings—other commentators have used higher costs estimates. Levin and Levin (2003) use a figure of $500,000, but admit that their figure is conservative (high) given that the average European opposition costs considerably less. To demonstrate the impact of substantially higher costs and to test the sensitivity of our results, we allow the costs for both opposition and appeal to be $200,000 in scenarios 5, 6 and 7, while we employ the very conservative estimate from Levin and Levin (2003) of $500,000 in scenarios 8, 9 and 10. Since scenarios 7 and 10 also use the lower bounds for litigation costs and social losses due to unwarranted, but unlitigated patents, the lowest benefit-cost ratios will occur in these "worst cases."

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[36] From survey evidence, Harhoff et al. reported that patents renewed full-term were worth 400,000 DM on average, and through estimation determined that patents surviving opposition were worth 11 times more. Adopting this figure and the constant foreign exchange rate of 2 DM = 1 Euro, we calculate (4.4 million DM = 2.2 million Euro) and (2.2 million Euro * 1.04^30 = 7.1 million Euro). Using the standard assumptions outlined above to calculate the deadweight loss, one-half of this value is approximately 3.5 million Euros of social cost for each opposed patent in our analysis.

When considering the outcomes summarized in Table 6, two results are particularly noteworthy. As in previous work described in Hall et al. (2003), the overall benefit cost ratios are sizeable and range in scenarios 1-4 between 4.0 and 15.6. We comment on the sensitivity of these estimates below. Second, and somewhat unexpectedly, a considerable share of the total net welfare gain W_{NET} comes from revocations in post-grant review of *presently non-litigated* patents. Given the high cost of litigation, a large number of patents that would be challenged in an inexpensive post-grant review system are not litigated in the current system. Carrying these patents in the system is likely to have considerable negative welfare consequences, insofar as they entitle the patent owner to excessive market power and may trigger costly "invent-around" expenditures by competitors. A post-grant review system that offers a comparatively low-cost challenge may have a higher likelihood of identifying such patents, and our analysis shows that approximately one third of these patents will be revoked and one third substantially narrowed if the situation unfolds in a manner similar to the European setting.

Naturally, the above estimates hinge critically on a variety of assumptions. Moreover, simply transferring the empirical probabilities from Europe to the US may not yield plausible results if the underlying cost structure and institutional setup of a future US post-grant review system deviate strongly from this framework. However, as our results show, changes in the actual litigation rate and costs in the US does not change the results dramatically, since overall social benefit will be largely determined by the welfare effects emanating from those cases that are not being litigated under the current legal framework.

This finding, that the overwhelming benefit from adopting an opposition system is likely to come from revoking invalid patents that are currently being missed by US court litigation, is an interesting aspect that has not been considered in detail in the current debate. The small difference in benefit-cost ratios for scenarios 1 and 2 are illustrative of this point (15.5 versus 15.6), and hold generally for the other scenarios we tested, thus leading us to report in Table 6 scenarios 2-10 only the more conservative results (i.e., the lower benefit-cost ratio produced by employing the 1% litigation rate assumption). One may argue that the favorable cost-benefit ratios depend crucially on the assumed welfare loss from errant market power. While such an argument is doubtless correct, it is only when we assume an implausibly low welfare loss per case of non-litigated, but erroneously granted patents (with opposition in Europe) of $440,000 (in scenario 1) and of $150,000 (in scenario 2), respectively, that the two sources of welfare gains (represented by W_1 and W_2) are on par with respect to their absolute net effects. Even in this case, the benefit-cost ratios for the overall post-grant review system would be at 3.1 in scenario 1 (litigation rate of 3.2%), but does drop near unity at 1.1 in scenario 2 (litigation rate 1%).

Both Hall et al. (2004) and Levin and Levin (2003) identified high opposition costs as the factor that would most likely erode social welfare in any changed US system. Accordingly, we treat opposition (and appeal) costs as a shift variable in scenarios 5-10 and test the sensitivity of our overall results by allowing these costs to climb to $200,000 (scenarios 5-7) and $500,00 (scenarios 8-10). These higher costs have the effect of increasing the sum of our equation (1.3) by a factor of 2 and 4.5, respectively, when compared to the baseline calculations (at a litigation rate of 1%) in scenarios 2-4. As a result, our scenarios 5-7 show overall benefit-cost ratios lowered by a factor of 2 (as compared to scenarios 2-4) while these same ratios in scenarios 8-10 are decreased by a factor of 4.5 (as compared to scenarios 2-4). Only when we assume a very low welfare loss per case of non-litigated, but erroneously granted patents of $1 million, coupled with very conservative opposition and appeal costs of

$0.5 million (in scenario 10), do our calculations show a cost-benefit ratio smaller than unity (0.8).

5 Discussion and Conclusions

This paper is the first of which we are aware that compares US litigated patents with their European "equivalent" patents. We demonstrate several novel methods of "twinning" US and European patents that may be used in empirical comparative international research. Our data collection, identification, and analyses enable us to investigate the implications of employing these different twinning methods in our data analysis. We are furthermore able to draw some powerful conclusions about the propriety of adopting a patent "post-grant review" in the United States.

Our analysis suggests that even the most valuable US patents, those that are inviting costly litigation in US courts, are not being granted EPO patent protection in about 20 percent of the cases. While some of this effect may be due to the different manner in which patentable subject matter is defined in the EPO (in software, for instance), higher quality standards at the EPO may also be playing a filtering role. Our evidence thus lends support to proposals in the patent reform movement to provide funding and quality control to USPTO examination processes.

More provocatively, our analysis and welfare calculations suggest that the benefit from post-grant review in terms of social welfare per year—when put in dollar terms—could be over $20 billion. The main parameter affecting this estimate is not savings on the cost of litigation, but the social costs of currently unlitigated patents that bestow excessive market power on some applicants. This market power either allows the patentee to extort licensing fees, or force competitors to “invent around” the respective patent. But even when we draw a conservative scenario, and assume a very low social cost figure of $1 million on average for these patents, our benefit-cost ratios still indicate that the benefits of such an institution compares very favorably to its costs. Only when we drive the social costs of opposition and appeal to a high figure of $0.5 million (each), and couple these with extreme (low) estimates for the cost of market power and litigation do the overall social costs significantly outweigh the benefits.

This latter point deserves particular attention. It is likely that any radical increase in the cost of post-grant review will alter our benefit calculations substantially (as shown in scenarios 5-10), not only by inflating the cost-side of the benefit equation, but also (to the extent that the demand for post-grant review is elastic with respect to price) by depressing the benefit that would flow from removing patents that bestow excessive market power. Several scenarios we have modelled demonstrate that radically higher post-grant review costs—on the order of the $500,000 used by Levin and Levin (2003)—would result in a cost-benefit ratio near, and in some circumstances less than, unity. As demonstrated in Hall, et al. (2004), it is likely that any welfare benefits that flow to society will be quickly eroded by a high-cost post-grant review procedure.

Not only should the system avoid burdening a patentee with substantial costs, but also because the system is designed to take advantage of information that resides with the patentee’s competitors about patent prior art, the process should avoid erecting cost barriers to them. This latter problem is particularly important given the “public good” nature of an invalidity decision: To the extent that the cost of such an invalidity outcome is increasing, the

incentives for potential challengers to "free ride" may rise, with the result that fewer worthy challenges will likely be brought. Our results thus contain an important reminder to policy-makers: costs of post-grant reviews need to be kept relatively low in order to achieve the intended improvement in patent system performance.

A number of important objections might be raised against the way in which we have set up the welfare calculations and the overall analysis. These are i) that we underestimate the impact that the introduction of post-grant reviews might have on smaller entitities and independent inventors who may become the target of larger firms in opposition proceedings, ii) that we neglect any form of type-II error cases in which patents are revoked that should be held valid, and iii) that we underestimate the danger of introducing an instrument that would be a precursor to, and a cause of more litigation rather than a substitute for litigation. We address these concerns in turn before addressing an additional issue—the role of courts in validating the decisions made by the post-grant review boards.

Underestimated negative impact on smaller entities. It has been argued that smaller firms and individuals would find themselves the targets of opposition and would be disadvantaged, to the extent that these entities have limited resources. A somewhat different, but related concern addresses the extent to which smaller entities engage in opposition. Since the *ex post* validity of unchallenged patents is always uncertain (Lemley and Shapiro 2004), smaller entities might use the post-grant challenge less often than is optimal if the institution imposes—with certainty—high costs. The system would consequently fail to incorporate the useful information about (in)validity that these smaller entities possess. However, these points raise the concern that a *high-cost* opposition mechanism may have disadvantages going beyond the ones we have captured with our welfare analysis.

In the European low-cost opposition system, these issues are apparently not a serious impediment for small entities. We queried the German patent attorneys we interviewed specifically about such a "small entity" effect. It was clear from our respondents, however, that individuals and small firms—instead of being disadvantaged by an opposition system—are instead advantaged. The much lower cost of purchasing a challenge (in comparison to full-fledged litigation) is seen as a substantial benefit to smaller entities. We conclude that because the costs of litigation create a significant disincentive to small firms seeking invalidation in patent litigation (Lanjouw and Lerner, 1997), a post-grant review offers the prospect of helping, not harming, small entities on balance. We also note that the results of two studies covering particular technologies have suggested that independent inventors are less, not more likely to see their patents become the target of opposition (Harhoff and Reitzig 2004, Graham et al. 2003). Harhoff (2005) uses data covering a broad range of technology classes and confirms that EPO patents owned by independent inventors are less likely to be attacked. However, the results also suggest that firms with large patent portfolios have an advantage in avoiding patent opposition.

All of these effects (to the extent that they are also present in the EPO system) are already included in our estimates. Hence, the concerns raised in the U.S. would only render our estimates suspect if the U.S. incarnation of a post-grant opposition system would create particularly strong detrimental effects. As we argued before, limiting the cost of a post-grant review mechanism is likely to be the best safeguard against such dangers.

Type-II errors in post-grant reviews. Another objection against our study, and against our welfare calculations in particular, could focus on the absence of any consideration of type-II errors that would lead to the erroneous revocation of patents that should have been upheld in

opposition, but were not. Such errors would constitute the source of additional welfare losses. While our study design can inform us about type-I errors (the likelihood with which the US system maintains patents that, according to a European standard, should have been revoked), it is difficult to think of a data-generating process that would let us estimate the extent of type-II errors. However, it is quite clear that the overall design of modern patents systems generates a playing field that is tilted in favor of the applicant rather than the examiner or patent office, i.e., very much in favor of type-I errors. In the context of the European patent system, applicants have recourse to various forms of appeal, for example against the negative outcome of examination or of opposition. Moreover, in the US reform proposals, parties involved in the planned USPTO post-grant reviews would be entitled to appeal decisions to the Court of Appeals for the Federal Circuit (CAFC). We also note that in all reform debates in the US, the focus has clearly been on the permissive character of the system, rather than its tendency to deny patent grants to applicants.

Opposition as a cause of litigation. It has been suggested that adopting an opposition mechanism in the US could actually increase the incidence of litigation, thus leading to an increase in the costs to patentees and altering the *ex ante* likelihood of patenting and the rewards to innovation. Court proceedings occur when legal controversies fail to settle (Lanjouw and Lerner, 1997). The law and economics literature has developed three theories to explain why disputes fail to settle, titled divergent expectations, asymmetric information, and asymmetric stakes (Cooter and Rubinfeld, 1989; Meurer, 1989). Generally: divergent expectations between the parties lead to litigation because subjective probabilities of success in the suit differ; asymmetric information over likely outcomes drives litigation because of the possibility of capturing information rents; and a party's asymmetric stakes in the controversy increases litigation because the party is willing to invest resources in litigation, even in the face of a low likelihood of prevailing.

Assuming an opposition system is well-tuned and produces correct results, opposition results would tend to lower uncertainty, and would be observable to all. The outcomes in such a system would tend to undermine the divergent expectations and asymmetric information explanations for litigation, but would be less likely to limit cases driven exclusively by asymmetric stakes.

Patent controversies arise from the actions of (at least) two parties, and are determined by the aggressiveness (willingness) of patent owners to enforce and the aggressiveness (willingness) of non-owners to infringe. The willingness of either party can be expected to be a function of their certainty over the validity of the patent. From either party's perspective, the information contained in an opposition outcome will tend to increase the likelihood of an efficient bargain absent sufficiently asymmetric stakes. While an outcome increasing the owner's certainty about the validity of the patent right is likely to increase the willingness of the owner to enforce the patent, this result is satisfactory. In our system, society has accepted a *quid pro quo* and seeks in policy to reward true inventiveness with monopoly. While the patentee may demand payments from the infringer which are passed to consumers, or even put the infringer out of business, society understands this outcome and (in law) accepts it as part of an effective patent system—so long as the patentee has a valid patent. To the extent that an opposition system can improve the certainty that the owner, the infringer, and society have over the validity of the patent, it may lead to efficient settlement, less litigation, and greater public legitimacy (considering the public as a consumer of news about the operation of the patent system).

This analysis suggests that high-quality opposition outcomes may tend to undercut two of the theorized causes of litigation, divergent expectations and asymmetric information (though not necessarily asymmetric stakes). But we also suggest that owners will be more willing to enforce patents against infringers when receiving an opposition outcome that increases their certainty over the (heightened) validity of the property right. Whether this willingness on the part of owners to enforce would lead to more litigation, however, is far from certain.

Are oppositions that result in either an amended or survived patent likely to lead to more, or less, *ex post* litigation? We must consider two endogenous reactions. When an opposition results in an amended patent or a rejection of the challenge, one can expect two countervailing effects. In amendments that undermine the validity of the patent, we expect this information about the weakening of the patent to create less incentive in the patentee to enforce, but also more incentive in the potential infringer to infringe. More or less litigation may result *ex post*. Similarly, a patent that has survived opposition unscathed can be considered stronger, and thus may create incentives for the patentee to be more aggressive in enforcement, but may create incentives in infringers (who have not made sticky investments) to move away from infringing activity. We may thus see again more or less litigation *ex post*. While teasing out these effects is beyond the scope of our paper, we believe that providing our probit analysis in Table 5 offers some descriptive value and offer them as such.

It has also been suggested that challengers might be reluctant to file oppositions because doing so would invite retribution in the form of an infringement action by the patentee—the so-called "painting a big red target on yourself" argument. Leaving aside the fact that current proposals would allow challenges to be brought to the Patent Office through an intermediary, the consensus among the small sample of German attorneys we interviewed was that such outcomes did not occur. In order to explore this issue quantitatively, we collected data on the incidence of patent annulment suits at the German Federal Patent Court (Bundespatentgericht - BPG). Since about 98% of all EPO patent grants designate Germany as a country in which patent protection is sought, the restriction to German court outcomes is not critical for our analysis. The BPG made available to us data on all 804 cases concerning EPO-granted patents that came to a decision between 1992 and 2003. Annulment suits can be initiated by third parties at any time during the statutory term of a patent, once opposition rights have been exhausted. These cases may be filed in the context of an infringement suit, but can also be filed independently. The data allow us to compute a litigation rate for opposed and for unopposed patents. Between 1986 and 1995 (a ten-year time window) a total of 269,760 patents which designated Germany were granted by the EPO. Oppositions were filed against 7.5% of these (20,150 patents). In 6,160 cases, the opposition was rejected (or withdrawn), and in 6,680 cases the patent had been amended. 7,280 patents had been revoked. Thus, 97.3% of the patents (262,480 – 249,610 without preceding, 12,870 with preceding opposition) "survived" the opposition stage and were thus a potential target of annulment suits. Annulment suits had been filed against 683 patents, 198 of which had been the target of an opposition prior and 485 which had not. Thus, annulment suits occurred for 0.19% of all unopposed patents, and for 1.54% of the previously opposed patents. The overall annulment suit incidence was 0.26% of all patents that had survived the opposition stage.

The most conservative (and somewhat unrealistic) assumption would be that opposition "caused" the difference in litigation rates between previously unopposed and opposed patents. This assumption is unrealistic because opposed patents concern particularly valuable inventions which are more likely to trigger infringement (and thus annulment suits, irrespective of a preceding opposition case). But even if we disregard this effect, in the case of German patents the revocation of 7,280 patents in opposition would have been accompanied

by a (hypothetical) rise of 198 cases in the number of annulment suits. Thus, this is clearly a second-order effect. Moreover, while the impact of opposition on litigation may cause additional costs, it is unlikely that the effect is fully detrimental. If opposition "hardens" legitimate patent rights, subsequent infringement litigation may very well support R&D incentives in a socially efficient manner, contrary to cases in which patents are involved that are objectively invalid, and thus should not have been granted in the first place.

We conclude that the three issues discussed above do not appear to be of major concern. They may indeed introduce second-order effects that could be considered in more detail, albeit at the expense of a considerably more complex analysis which we do not pursue here. Some of the concerns are likely to become more serious issues in the context of a high-cost post-grant review system. Thus, our discussion emphasizes the earlier point that post-grant reviews need to be "inexpensive" in order to bring about the desired positive consequences.

At the conclusion of this discussion we comment on one additional concern that would indeed threaten the functional effect of any post-grant review system. Under US law, the determinations of an administrative proceeding are due a review by the judicial branch, and thus the Court of Appeals for the Federal Circuit (CAFC) will likely play a role in controlling costs. Evidence suggests that the CAFC has not been deferential to the validity determinations of district court judges: while the reversal rates in the Courts of Appeal in all civil matters is approximately 10%, the CAFC reverses 50% of the district court validity decisions (Chu, 2001). This practice in the CAFC has the effect of shifting substantial costs to the litigating parties. An over-active reversal posture toward the determinations of post-grant review would have the effect of raising the likelihood of appeals, of raising the costs of the process, and of eroding the welfare benefits we have demonstrated in our calculations. Quillen (2005) criticizes the post-grant review proposals for this particular reason, arguing that without raising the standards of patent examination and review in the US courts, an opposition system would not be able to contribute to an improved overall patent system. It is partly for this reason that previous studies offered a menu of recommendations for patent system reform, recognizing that these reforms operate together as a system (The National Academies, 2004; Jaffe and Lerner, 2004). Because a post-grant review system is mentioned prominently in these reports, we offer our study to allow more informed debate about the propriety of adopting such a change.

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Figure 1

Family Relationships between Patent Documents

Document D1	**Priority P1**		
Document D2	**Priority P1**	**Priority P2**	
Document D3	**Priority P1**	**Priority P2**	
Document D4		**Priority P2**	**Priority P3**
Document D5			**Priority P3**

Source: http://www.european-patent-office.org/news/epidosnews/source/epd_4_00/14_4_00_e.htm

Figure 2

EPO Opposition Frequency for Equivalents of
Litigated and Control Group Patents

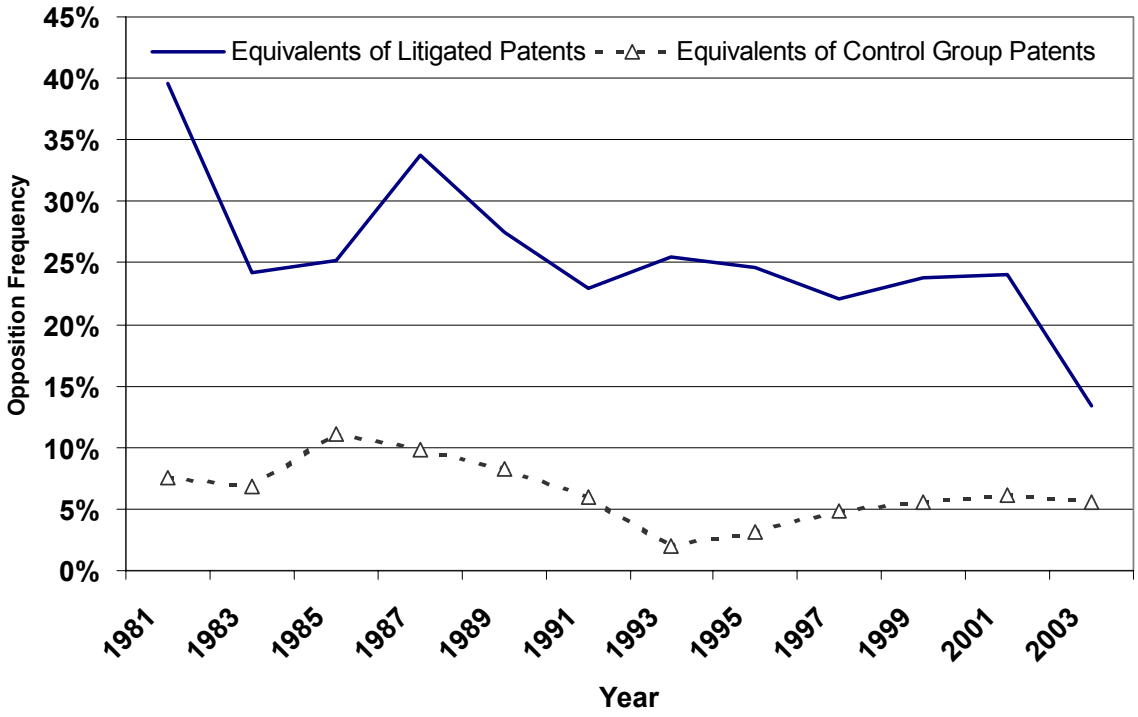

Table 1
EPO Matching Results for US Litigated and Matched US Control Group Patents

	18,033 Litigated US Patents (application year 1977 or later)	18,033 Control Group Patents (application year 1977 or later)
EPO Equivalents Found	3,342 US patents (3,424 EPO applications)	3,206 US patents (3,328 EPO applications)
EPO "Family" Patents Found	(4,590 EPO applications) [including 3,424 equivalents]	(4,096 EPO applications) [including 3,328 equivalents]
EPO "Extended Family" Patents Found	(7,728 EPO applications) [including 4,590 family patents]	(7,045 EPO applications) [including 4,096 family patents
EPO Equivalents for Matching US Litigated and Control Group Patents	923 US patents (942 EPO applications)	923 US patents (944 EPO applications)
EPO Equivalents for Litigated US Patents Only	2,419 US patents (2,474 EPO applications)	0
EPO Equivalents for US Control Group Patents Only	0	2,283 US patents (2,304 EPO applications)
No EPO Equivalents	14,691 US patents	14,827 US patents

Table 2
Descriptive Statistics for EPO Equivalent Applications of
Litigated and Non-Litigated USPTO Patents – Paired and Unpaired Comparisons

	Test[#] (1) vs. (4)	Test[#] (2) vs. (3)	(1) EPO equivalents of litigated US patents	(2) EPO equivalents of litigated US patents	(3) EPO equivalents of non-litigated US patents	(4) EPO equivalents of non-litigated US patents
			no EPO equivalent for matching unlitigated US patent	EPO equivalent for matched pairs of litigated and non-litigated US patent		no EPO equivalent for matching litigated US patent
equivalent EPO applications (US patents)	-	-	2,474 (2,419)	942 (923)	944 (923)	2,304 (2,283)
examination outcomes	-	-				
• application pending	-	-	9.4	4.8	4.8	8.7
• grant	-	-	68.9	80.3	67.9	59.5
• application withdrawn or consolidated	-	-	18.7	11.5	22.6	27.7
• grant effectively refused by EPO	-	-	3.0	3.3	4.8	4.0
number of claims in application*	<.0.01	<.0.01	18.32 (0.29)	16.48 (0.46)	13.67 (0.33)	15.67 (0.25)
number of references to other patents*	<.0.01	<.0.01	5.21 (0.07)	4.65 (0.10)	4.26 (0.09)	4.49 (0.06)
share of X references*	0.24	0.50	17.62 (0.54)	16.61 (0.86)	15.78 (0.90)	16.78 (0.57)
share of Y references*	0.05	0.50	15.26 (0.52)	13.45 (0.78)	12.70 (0.79)	13.80 (0.53)
EPO citations received within 5 yrs*	<.0.01	<.0.01	4.18 (0.11)	5.46 (0.22)	2.64 (0.11)	2.37 (0.07)
share of X citations received within 5 yrs*	0.18	<.0.01	8.79 (0.41)	8.13 (0.57)	5.51 (0.53)	7.98 (0.44)
share of Y citations received within 5 yrs*	0.078	<.0.11	6.59 (0.35)	6.17 (0.49)	5.00 (0.54)	5.70 (0.37)

Source: Authors' computations from ESPACE and EPOLINE data. Data on the number of claims was supplied by the EPO from its internal EPASYS database.
* Mean value, standard errors in parentheses. [#] Test on differences in means or on differences in distribution of outcomes, p-values.

Table 3
Descriptive Statistics for EPO Equivalent Patent Grants of
Litigated and Non-Litigated USPTO Patents – Paired and Unpaired Comparisons

	Test[#] (1) vs. (4)	Test[#] (2) vs. (3)	(1) EPO equivalents of litigated US patents	(2) EPO equivalents of litigated US patents	(3) EPO equivalents of non-litigated US patents	(4) EPO equivalents of non-litigated US patents
			no EPO equivalent for matching unlitigated US patent	EPO equivalent for matched pairs of litigated and non-litigated US patent		no EPO equivalent for matching litigated US patent
equivalent EPO patent grants (US patents)			1,923 (1,873)	564 (548)	565 (548)	1,457 (1,441)
time to grant (years)	<0.01	0.21	4.11 (0.05)	3.56 (0.08)	3.42 (0.08)	3.71 (0.05)
opposition rate	<0.01	<0.01	18.6	24.2	7.5	5.0
opposition pending			25.1	14.8	9.5	25.8
opposition outcomes (non-pending cases)	<0.21	<0.14				
• patent revoked			22.6	24.4	39.5	28.9
• opposition rejected			24.8	24.4	23.7	34.6
• patent amended			38.0	38.3	34.2	26.9
• opposition closed			14.7	13.0	2.6	9.6
opposition outcomes (consolidated)	<0.27	<0.86				
• patent revoked or lapsed			32.3	34.8	39.5	34.6
• opposition rejected or withdrawn			29.7	27,0	26,3	38.5
• patent amended			38.0	38.3	34.2	26.9
appeal rate	<0.01	<0.15	50.7	55.6	42.9	27.8

Source: Authors' computations from ESPACE and EPOLINE data. Data on the number of claims was supplied by the EPO from its internal EPASYS database.
* Mean value, standard errors in parentheses. [#] Test on differences in means or on differences in distribution of outcomes, p-values.

Table 4
Descriptive Statistics for EPO Equivalents and Non-Equivalent Family Members
of Litigated U.S. Patents and for Matched EPO Patents

	Test (1) vs. (2)	(1) EPO equivalents of litigated US patents N=3,386	(2) EPO Patent Applications Matched to (1) N=3,386	Test (3) vs. (4)	(3) Non-equivalent EPO family members of litigated US patents N=4,286	(4) EPO Patent Applications Matched to (3) N=4,286
share of applications granted	-	72.1	72.1		57.2	57.2
share of applications pending	-	8.1	8.1		20.4	20.4
number of claims in application*	<0.01	17.8 (0.25)	15.0 (0.20)	<0.01	21.9 (0.33)	16.4 (0.20)
number of references to other patents*	<0.01	5.05 (0.06)	4.52 (0.05)	<0.01	4.89 (0.05)	4.26 (0.04)
share of X references*	0.51	17.39 (0.46)	16.94 (0.48)	<0.01	22.26 (0.46)	20.50 (0.46)
share of Y references*	0.01	14.77 (0.44)	13.27 (0.43)	<0.01	17.63 (0.43)	13.77 (0.39)
EPO citations received within 5 yrs*	<0.01	4.48 (0.10)	2.07 (0.05)	<0.01	3.08 (0.08)	2.07 (0.05)
share of X citations received within 5 yrs*	0.03	8.55 (0.34)	7.49 (0.34)	<0.01	11.09 (0.37)	9.36 (0.36)
share of Y citations received within 5 yrs*	<0.01	6.44 (0.29)	4.29 (0.27)	0.47	5.10 (0.24)	5.35 (0.26)
time to grant (years)*	<0.01	3.99 (0.04)	3.64 (0.040)	<0.01	5.35 (0.06)	3.96 (0.05)
opposition rate	<0.01	19.7	6.4	<0.01	22.3	6.4
opposition pending	<0.01	22.0	15.3	<0.01	36.1	20.1
opposition outcomes (non-pending cases)						
• patent revoked		22.9	36.1		29.7	37.6
• opposition rejected		25.0	22.6		21.4	18.8
• patent amended		38.0	33.6		38.5	36.9
• opposition closed		14.1	9.8		12.0	5.1
opposition outcomes (consolidated)						
• patent revoked or lapsed		32.7	39.9		37.1	40.2
• opposition rejected or withdrawn		29.3	28.7		26.0	21.4
• patent amended		38.0	31.6		36.9	38.5
appeal rate	<0.01	51.9	26.5	<0.01	44.3	37.7

Source: Authors' computations from ESPACE and EPOLINE data. Data on the number of claims was supplied by the EPO from its internal EPASYS database.
* Mean value, standard errors in parentheses. Test results are obtained from simple t-tests or binomial tests (in the case of share variables).

Table 5
Multivariate Results from Probit Regressions
of Opposition Incidence

	(1) Sample Means (relative to reference group)	(2) Probit Marginal Effect (Standard error)	(3) Probit Marginal Effect (Standard error)
EPO equivalent to litigated US patent (n = 1,443)	0.1211	0.1223 (0.0102)	0.0692 (0.0083)
EPO non-equivalent family member of litigated US patent (n = 1,126)	0.1676	0.1577 (0.0123)	0.0902 (0.0101)
N	122,568	122,568	122,568
Control variables	none	Time/technical field dummies - see below	time/technical field dummies additional control variables - see below
log L	-	-27319.0	-26192.8
Pseudo R-squared	-	0.0496	0.0887

Note: Results in columns (2) and (3) are from probit regressions as described in Harhoff (2005). The sample was restricted to EPO patents granted before Dec. 31, 2000 with US priorities. The reference group for the litigation dummy variables contains all observations that were not identied as equivalents or familiy members of US litigated patents.

Control variables in column (2) include 20 time dummies for grant years and 29 technical field dummies derived from IPC classifications. Additional control variables in column (3) include: number of citations, number of references, share of X citations, share of X references, share of Y citations, share of Y references, share of self citations, share of self references, number of designated countries, appeal against grant refusal (0/1), request for accelerated examination (0/1), PCT application (0/1), applicant portfolio size, Herfindahl of patent ownership concentration in technical area, independent inventor (0/1), university applicant (0/1), number of claims, third-party observations during examination (0/1).

Table 6
Welfare Calculations

	Parameter	Scenarios									
		1	2	3	4	5	6	7	8	9	10
	Current System Parameters										
S_L	social cost of litigation	$4	$4	$4	$2	$4	$4	$2	$4	$4	$2
S_{NL}	social cost of non-litigated revocable patent	$4	$4	$2	$1	$4	$2	$1	$4	$2	$1
p_L	probability of litigation without post-grant system	0.032	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011
	GH Estimates (Table 4, weighted averages)										
$p_{O,L}$	probability of opposition - litigated patents	0.198	0.198	0.198	0.198	0.198	0.198	0.198	0.198	0.198	0.198
$p_{O,NL}$	Probability of opposition - non-litigated patents	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058
$p_{R,L}$	probability of revocation - litigated patents	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354
$p_{R,NL}$	probability of revocation - non-litigated patents	0.330	0.330	0.330	0.330	0.330	0.330	0.330	0.330	0.330	0.330
$p_{PR,L}$	probability of partial revocation - litigated patents	0.313	0.313	0.313	0.313	0.313	0.313	0.313	0.313	0.313	0.313
$p_{PR,NL}$	probability of partial revocation - non-litigated patents	0.381	0.381	0.381	0.381	0.381	0.381	0.381	0.381	0.381	0.381
$p_{A,L}$	probability of appeal – litigated patents	0.520	0.520	0.520	0.520	0.520	0.520	0.520	0.520	0.520	0.520
$p_{A,NL}$	probability of appeal – non-litigated patents	0.325	0.325	0.325	0.325	0.325	0.325	0.325	0.325	0.325	0.325
	Opposition Cost Estimates										
C_O	cost of opposition	0.10	0.10	0.10	0.10	0.20	0.20	0.20	0.50	0.50	0.50
C_A	cost of appeal against opposition outcome	0.10	0.10	0.10	0.10	0.20	0.20	0.20	0.50	0.50	0.50
	Welfare and Total Cost Estimates										
W_1	welfare gain from avoided litigation	2,588	889	889	445	889	889	445	889	889	445
W_2	welfare gain from revocation of questionable patents without litigation	23,378	23,886	11,943	5,971	23,886	11,943	5,971	23,886	11,943	5,971
C_L	cost of opposition – litigated patents	193	66	66	66	132	132	132	331	331	331
C_{NL}	cost of opposition - non-litigated patents	1,488	1,520	1,520	1,520	3,040	3,040	3,040	7,600	7,600	7,600
W_{NET}	total net benefit	24,286	23,189	11,246	4,830	21,602	9,660	3,244	16,844	4,901	(1,515)
BC_{total}	overall benefit-cost ratio	15.5	15.6	8.1	4.0	7.8	4.0	2.0	3.1	1.6	0.8

Note: all cost and benefit figures in million US$.

Appendix A

As a validity check, we benchmarked our data against the results reported from data used in two prominent studies of patent litigation (Somaya 2003; Lanjouw and Schankerman, 2001), datasets reported by the authors as reasonably comprehensive representations of patent litigation in the United States. Our Figure 1 demonstrates that the sheer number of patents litigated has been growing steadily since the 1960s, but has not appeared to change markedly as a share of applications filed. As such, our data demonstrate a pattern roughly consistent with data presented in Somaya (2003),[37] although our data shows two important differences. First, our data are more complete in the later years, a consequence of the lagged nature of litigation events (we collected our data in 2005 while Somaya collected data in 1999-2000 for the 2003 paper). Second, our data appear to be more comprehensive in the early years. This finding is not necessarily inconsistent with Somaya's findings, in that he reports, and analyzes throughout the article, cases filed per patent while we report litigated patents (by application year). Thus, the underreporting of cases by the District Courts to the USPTO that Somaya cites in his article in the early years of his study (prior to 1983) is unlikely to have as marked an impact on patents in the earliest years of our sample (prior to 1975) because we are matching on application date and there exist long lags between patent application and patent litigation. Another explanation may be that our data is in fact more comprehensive in these early years: Westlaw™ announces that its litigation data is supplemented—which may indicate that it has found a source for these "missing" data.[38]

[Figure A1 about here]

[Figure A2 about here]

We also benchmarked our data against statistics reported by Lanjouw and Schankerman (2001). Our Figure 2 demonstrates that the litigation rate for granted patents year-on-year (based on application year) fluctuates between 6.8 per thousand and 9.5 per thousand from 1975-1995, with an apparent growth in litigation rates through 1995 until right censoring becomes apparent in the statistics for years after 1995. These figures are roughly consistent with statistics detailed by Lanjouw and Schankerman, who report 10.7 cases *filed* per thousand patents 1980-84, and 6.3 patents per thousand that show a litigation event in their lifetime. Our figure for the same time period (1980-84), by application year, is 8.0 litigated patents per thousand. Our larger share may be the result of more cases having been revealed over time, or that our data are indeed more comprehensive as a result of data collection in the Westlaw™ database.[39]

[Table A1 about here]

Lanjouw and Schankerman (2001) also report statistics for litigation in broad technology classes, and compare the characteristics of litigated and non-litigated patents, thus allowing us to further benchmark our data. We summarize their findings, and ours, in Table 1, in which we apply the same technology-class and application-year definitions used in Lanjouw and

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[37] Somaya reports cases filed from 1975-95 (Somaya, 2003: Figure 1).

[38] "The LITALERT (Patent and Trademark Litigation Alert) database contains records for patent and trademark litigation lawsuits filed in ninety-four US District courts that have been reported to the Commissioner of the United States Patent and Trademark Office (USPTO). Also included are records for thousands of lawsuits filed since the early 1970's that have never been published in the Official Gazette." Westlaw.com.

[39] Ibid.

Schankerman to our data.[40] The table demonstrates that the technology field effects for cases filed per thousand patents and patents litigated per thousand (when the technology effects are compared to the sample mean) are roughly equivalent, and virtually identical when compared to the means in each sample. We surmise that differences reflect the fact that patents in these technology classes are more likely to be involved in multiple suit filings.

Appendix B

We test our priors concerning "value" correlates of US patents by examining the number of claims, forward citations, and grant lags of both the (1) litigated sample and the (2) litigated sample for which we found EPO equivalents, comparing these against our control group (unlitigated) patentsUS. We note at the forefront that the incidence of litigation has been shown to be positively correlated with other indicators of patent "value." Our number of observations is somewhat smaller in these samples because full data on these characteristics was available only through 2002 grants. Our results are summarized in Table B1.

[Table B1 about here]

As we anticipated, the mean number of claims for litigated US patents is significantly higher than for US control group patents. Moreover, the mean number of claims in litigated patents for which an EPO equivalent exists is again significantly higher than the sample of litigated patents. This finding suggests to us, consistent with findings in Lanjouw and Schankerman (2001), that the number of claims is positively correlated with patent value. However, a larger number of claims may actually be a cause of litigation if additional claims increase the probability of conflicts between patent owners.

Table B1 also contains information on the number of citations received by our US patents. Our litigated patent sample shows a nearly three-fold increase in the number of forward citations as compared to control group (unlitigated) patents, and that factor rises to a more than four-fold increase when we compute the statistics for litigated patents for which an EPO equivalent exists. Both comparisons yield highly significant test results. These results suggest to us that both litigation, and the combination of litigation and seeking a patent in the EPO, are positive and significant value indicators for US patents.

We also compute the likelihood that a patent applicant used the "continuation" procedure in the US Patent Office, and the added associated grant lags. The continuation, essentially a procedural revision of a patent application that allows the applicant added time in examination, has been associated with secrecy strategies (Graham, 2004) and with other value correlates (Graham and Mowery, 2004). We find that continuations occur in approximately 27% of the patent applications of our control group sample, while about 42% of our litigated patents show a continuation application lineage. Interestingly, litigated patents for which there is an EPO equivalent are much less likely to issue after a continuation, with only about 12% of these patents showing continuation process. We surmise that the rewards to using

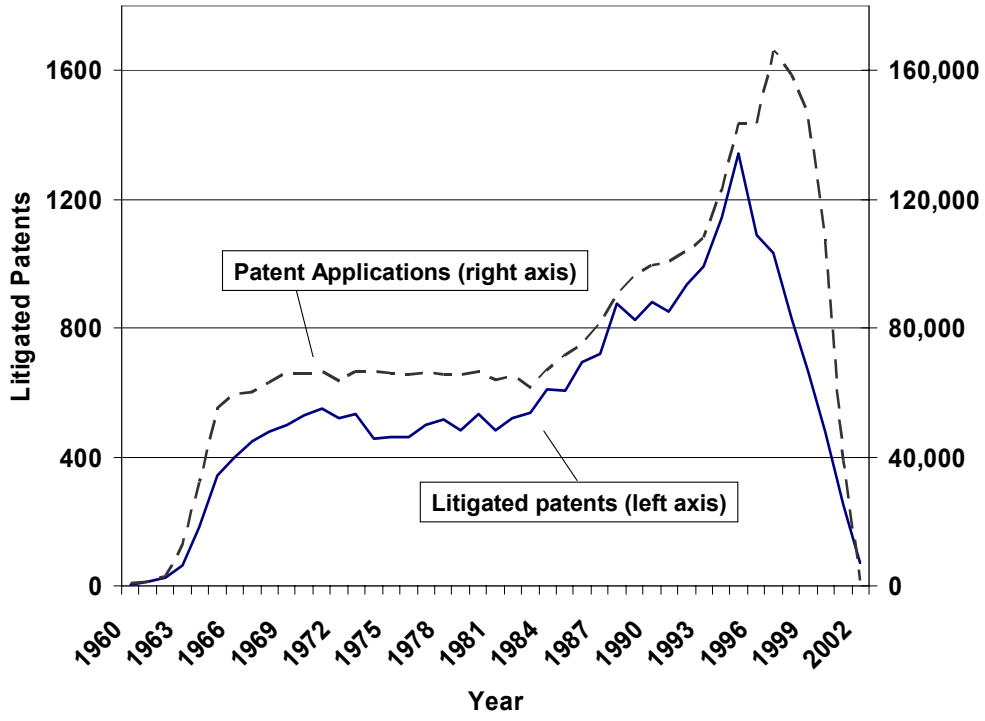
[40] "The IPC [international patent class] categories included in each of these groups are: Drugs and Health: A61 and A01N; Chemical: A62, B31, C01–C20, D–; Electronic: G01–G21, H–; Mechanical: B21–B68 not including B31, C21–C30, E01–F40." Lanjouw and Schankerman (2001), Table 1. They use patents with application dates 1980-1984, as do we for this comparison, although we drop the very small number of patents issued after their original working-paper date of 1997 (0.02% of our sample).

continuation may be significantly blunted by the publication rules in Europe, although a complete explanation is beyond the scope of this paper.

Our results in Table B1 make it clear that calculating time from application to grant using the "application date" listed on the patent produces significant, but not large, differences between the litigated and control samples. Consistent with findings in Graham (2004), using the first "continuation application" date to calculate grant lags in these US patents yields much more substantial, and interesting, differences. For the litigated patent sample, continuation grant lags (3.48 years) are some 46 weeks longer than the mean for all patents (2.60 years). However, reflecting the reduced use of continuations among US applicants also seeking EPO patents, grant lags are actually lower for these patents (2.25 years) than for our control patents. The implications of these findings, and the insights they may offer to strategic international patent application procedures are beyond the scope of this paper, but demand further research. In sum, however, our findings support those of earlier research: litigated US patents suggest in their manifest and latent characteristics added efforts by their applicants, and exhibit indications of value (Lanjouw and Schankerman, 2001; Hall, et al. 2004).

Appendix Figure A1

Comparison, US Patent Applications, and
US Litigated Patents, by application year



Appendix Figure A2

Share of U.S. Patents Involved in Litigation, by Application Year

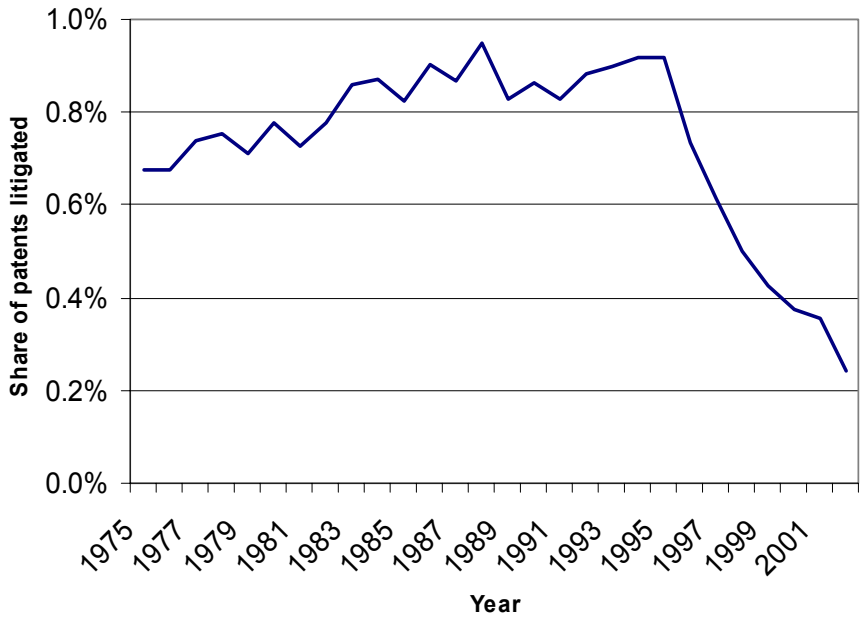


Table A1
Comparison of Lanjouw & Schankerman (L&S)
and Graham & Harhoff (G&H) Litigation Data

	L&S cases litigated	share of mean	G&H patents 1970-79	share of mean	G&H patents 1983-93	share of mean
All sample mean	**10.7**	- -	**7.5**	- -	**8.7**	- -
Drugs and health	20.1	1.9	10.6	1.4	14.3	1.6
Chemical	5.4	0.5	3.3	0.4	4.4	0.5
Electronics	9.6	0.9	7.6	1	8.2	0.9
Mechanical	11.8	1.1	6.6	0.9	8.6	1.0

Note: L&S data from Lanjouw and Schankerman (2001)
L&S: cases filed per thousand patents (by technology class) 1980-1984
G&H: patents litigated per thousand patents issued (by application date), 1970-79 and 1983-93.

Table B1

Descriptive Statistics for U.S. Control-Group Patents, Litigated U.S. Patents, and Litigated U.S. Patents with EPO Equivalents

	Test (1) vs. (2)	(1) US Litigated Patents, application dates 1977-2002 N=18,033	(3) US Control Patents, application dates 1977-2002 N=18,033	Test (2) vs. (3)	(3) US Patents Litigated, with EPO equivalents, application dates 1977-2002 N=3,382
number of claims in patent*	<0.01	17.9 (0.15)	13.6 (0.01)	.11	20.7 (0.44)
Percent of patents in which country of first inventor residence is U.S.	-	83.8	83.8	<0.01	73.8
US citations received through 2002*	<0.01	16.3 (0.22)	7.9 (0.01)	<0.01	23.3 (0.73)
Percent of patents using continuation application process	<0.01	41.7 (0.36)	27.4 (0.02)	<0.01	11.7 (0.53)
time to grant, application date (years)*	.23	2.02 (0.01)	2.00 (0.00)	.24	2.10 (0.02)
time to grant, continuation date (years)*	<0.01	3.48 (0.02)	2.60 (0.00)	<0.01	2.25 (0.02)

Source: Authors' computations from USPTO, Micropatent, and NBER data.

* Mean value, standard errors in parentheses. Test results are obtained from simple t-tests or binomial tests (in the case of share variables).