An Empirical Investigation of Patent Races: Evidence from Patent Priority Disputes at the U.S. Patent and Trademark Office

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Preliminary version – comments welcome
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Abstract:

This paper studies the impact of patenting on competition in research and innovation by analyzing patent priority disputes in the United States. The U.S. Patent and Trademark Office resolves priority disputes in patent interference cases. We analyze a random sample of interference cases declared between 1988 and 1994. Their distribution across technology classes suggests that patent racing is common in industries with strong patent rights, consistent with the predictions of the theoretical literature. We also find evidence that incumbent firms are slow to file patent applications, supporting the hypothesis that conditional on obtaining patent rights, incumbents have incentives to delay innovation relative to challengers. Our results have implications for patent policy in general and for evaluating the U.S. "first to invent" patent priority rule.

Keywords: patent race; patent interference; US Board of Patent Appeals and Interferences; patent litigation; innovation; research and development.

JEL Codes

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1. Introduction

A central question of innovation policy is whether patents encourage or retard the diffusion of new ideas and technology, and, in consequence, how extensive patent rights should be. Largely absent from the debate are the welfare consequences of patent races. A substantial theoretical literature investigates how competition for a patent – a patent race – affects dynamic competition, the level of investment in research and the rate of innovation. Under some circumstances, patent races can (in theory) lead to excessive expenditures on invention, preemptive patenting, and delayed innovation.

The purpose of this paper is to consider empirical evidence for patent races. Our analysis is based on an examination of interference cases declared by the US Patent and Trademark Office (USPTO) between 1988 and 1994. The data are far from ideal, so our conclusions are necessarily tentative. However, we believe that they provide sufficient support for the theory that patent race implications should be a serious part of the patent policy debate.

Patent interferences are the means by which the USPTO resolves priority disputes between patent applicants. The existence of an interference means that two or more inventors have credible claims to the same invention, as would happen in a photo-finish patent race. A race with a clear winner should not involve interference litigation, thus the case data we analyze here is only the tip of the potential patent race iceberg.

On the other hand, while interference litigation requires that firms conduct duplicative research, it does not imply that the duplication was by design or that the interfering parties were strategically racing against each other. The first part of this paper presents data on the distribution of interferences across technology categories to argue that the cases are consistent with strategic racing but not with (or not exclusively with) alternative reasons for why an interference might arise. Furthermore, we show that the pattern of interferences is likely to reflect broader research duplication rates in industry rather than a non-representative selection based on the preferences of the parties for litigation.

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Using the interference data as a representation of patent racing, we test predictions from the patent race literature about incentives to innovate for incumbent and challenger firms. The data provide preliminary support for the classic Arrovian hypothesis that incumbents delay the introduction of innovations relative to challenger firms. Moreover, the U.S. patent system is likely to exacerbate this strategic behavior.

Patent interferences exist to support the unique American first-to-invent patent standard. All other countries award patents to the inventor who is the first to file for a patent on the invention – a standard that requires little litigation to determine priority. U.S. patents are awarded to the inventor who (with qualifications) proves that he invented the invention first, even if someone else has filed for a patent in the interim. Thus the U.S. patent system allows inventors (again, with qualifications) to delay filing for a patent, with its requisite expense and divulging of research results, and yet not forfeit subsequent rights to the invention.

The first-to-invent standard impedes patent harmonization with other countries. Thus, in addition to the light that patent interferences shed on the research and development process in industry, the impact of the first-to-invent system more generally is important to the debate over whether the U.S. should change its patent priority standard to further harmonization. Several studies have suggested that the interference process is rarely used, and that in consequence its demise would have only a minimal impact on patent activity in the United States.[1] Critics of the U.S. standard also challenge the claim that first-to-invent has desirable distributive characteristics; specifically, that it benefits small firms and individuals who disproportionately contribute to socially desirable innovation.[2]

Our results are in part at odds with these studies. We find that there were a non-trivial number of interferences during our study period: from 1988 to 1993, over 1400 new interference cases were declared. Among technologies where patents are traditionally thought of as strong, the likelihood that an application will be involved in an interference is nearly as high as, and in some cases higher than estimates of infringement rates.[3] Furthermore, we find that the assignment of rights under the first-to-invent and first-to-file rules are more likely to differ for less derivative patents, which are arguably of greatest interest to innovation policy.

Alternatively, we find no evidence that the interference procedure benefits (or, for that matter, harms) small firms. Indeed, most of the firms that participate in patent

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1 Lemley and Chien (2003), Mossinghoff (2002). Another recent study of interferences that raises some of the issues addressed here is Kingston (2004).

2 Representative Lamar Smith introduced legislation in Congress on June 8, 2005 that (among sweeping reforms) proposes changing the U.S. system to a first-to-file standard. See the News Release on Congressman Lamar's web site, at http://lamarsmith.house.gov/news.asp?FormMode=Detail&ID=648.

3 The incidence of infringement cases soared during the 1990s, while that of interferences appears to have dropped. Due to the long lag in the distribution of cases, we cannot speculate in an informed manner on the change in interference patterns. The key comparisons here regarding absolute and relative risks in different technology classes remain valid for recent infringement rates as well as those based on data from years coterminous with our sample. See Lanjouw and Schankerman (2001), Lanjouw and Schankerman (2005).

interference cases are very large, consistent with the expectation that patent races are the province of corporate research laboratories with well-defined goals and good information about the activities of the competition. Finally, as is mentioned above, our evidence suggests that the first-to-invent policy can exacerbate some socially inefficient aspects of patent races.[4] The priority standards thus appear to have a significant impact on who patents and when, and the interaction between the standards and the conduct of R&D deserves a closer look.

The paper proceeds as follows. The next section introduces the patent interference process, provides some details about when and how the process can be used and presents summary statistics about interferences based on our sample. Section 3 discusses key predictions from the patent race literature and our strategy for identifying interferences as patent races. Section 4 addresses the rate of interfering in different industries and compares patent applications subject to interference suits to those in the population at large. Section 5 relates outcomes in interference cases to the incumbency-challenger debate, and investigates who wins interference cases. In section 6 we conclude with a discussion of the implications of these results for patent policy.

2. Interference Cases at the US Board of Patent Appeals and Interferences

U.S. patent priority rules are currently based on the principle that the first person to invent a patentable invention should receive the patent. When two or more parties claim to satisfy that standard, a patent examiner can declare an interference proceeding to determine priority.[5] We consider here some features of declarations, the different kinds of cases, and the different kinds of outcomes in these cases. Interference cases and rules are remarkably complex, and we discuss here only some very general issues that affect the way that we formulated our hypotheses and interpreted our results.[6]

2.1. Declaring an interference.

An interference declaration has two main components. First, the patent examiner identifies one of the parties as the senior party and the other party (or parties) as the junior party (junior parties). Each party is awarded a "benefit date," usually based on when their respective applications are filed. The senior party has the earlier benefit date, and thus was the first to file, although, as is discussed below, the "filing" need not be to the particular patent application in the interference. The other key piece of the interference declaration is the "count" (or counts) which state precisely what technology is in dispute. The declaration also identifies which claims in the patents or patent applications of the parties correspond to the interference count. The senior party starts out with a presumption of priority, and the junior party has the burden of proof to show that he invented first.

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[4] Our conclusions are anticipated by Gholtz (2000). See section 6, below.

[5] Formally, the Commissioner of Patents declares the interference but the examiners appear to call the shots.

[6] See Kingston (2004) for an overview of Patent Interference practices, and Lipscomb (1986) for details, including a history.

The PTO explicitly encourages interference parties to settle with each other. As part of a settlement, one party will relinquish his claim to the technology; that resolution, along with any side-deals, must be reviewed and approved by the BPAI, although only the resolution of the claim, and not any associated arrangements, are made public. If the parties do not settle, the case is decided by a three-member panel from the BPAI. Panel members are called patent trial judges; they are experienced patent examiners.[7] The BPAI panel issues a final statement in all cases stating the resolution of the interference and the patent status of the disputed technology.

Some interferences settle quickly, others can go on for years and involve hearings and massive amounts of evidence. For interferences declared between 1988 and 1994, the minimum time to conclusion was sixteen days and the maximum over ten years. The average time to conclusion was 623 days. The BPAI issued a final decision in 23% of the cases. Settled cases took an average of 412 days (between declaration and issuance of a final judgment) and cases decided by the Board took an average of three and a half years. Like all administrative decisions, BPAI decisions can be appealed to the federal courts.[8]

2.2 Types of Interferences

Unlike infringement cases, private parties cannot sue for interference. However, they can alert patent examiners to a potential interference, and request that one be declared. Knowledge of a potential interference arises in three circumstances, which define the three distinct types of interferences. Examiners generally identify an interference when it involves two applications ("applicant only"). Applications are sent to examiners at the PTO who specialize by technology so that two interfering applications would most likely be examined by the same examiner (certainly in the same group). Second, the senior party may have a patent, and the junior party an application pending before the PTO ("senior party patentee"). The examiner may recognize the interference or the junior party request one on the basis of the senior party's published patent. Junior parties can file for a patent up to a year after the issuance of the senior party's patent and request an interference, but it is much more common for the applications to be co-pending. If the applications are not co-pending, the burden of proof on the junior party rises from a preponderance of evidence standard to beyond reasonable doubt. Both applicant-only and senior-party-patentee cases are called interferences "for" the junior party, as they provide an opportunity for the junior party to claim rights that would otherwise be assigned to the senior party.

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[7] There have been changes in the titles and formal responsibilities of the panel members over the 1990s; however their experience, background and role in the interferences has remained basically stable.

[8] These statistics are based on our sample, described below. No comparable statistics for the population of interferences exist, but these numbers, and the other charateristics described here, are very close to those published by Calvert and Sofocleous (1989; 1992; 1995) for the population of patents distributed in the late 1980s and early 1990s. Our interferences were just being declared in those years and many were distributed years later, but there is significant overlap between the two sets of cases.

The third form of interference that the PTO handles is when the junior party has a patent and the senior party has an application ("junior party patentee").[9] These are the most common form of interference, and in them, the senior party has usually filed his application after the junior party and has requested the interference. The senior party obtains filing priority by having either a foreign patent or a parent patent. Thus the benefit date for the senior party corresponds to the application filing date for a different patent that incorporates the critical component of the interference count. This form of interference is considered an interference "for" the senior party, who has an opportunity to dispute a patent awarded to the junior party.[10]

Table 1 gives the incidence of each of these forms of interference and the basis for the benefit dates awarded to the junior and senior parties. In more than half of all interferences, the junior party has a patent and the senior party an interfering application. Applicant-only and senior-party-patentee interferences occur in about equal numbers, but in virtually all of the latter cases the parties initially had co-pending applications so that the burden of proof on the junior party is technically identical.

2.3 Interference Outcomes

Whether the interference is resolved by settlement or the BPAI, the result is one of four outcomes. The subject matter can be awarded to the senior party or to one of the junior parties. Both may actually wind up with patents, if the losing party still has a patentable invention absent the claims that correspond to the interference count. These are the possible "priority outcomes" for the case, and are the focus of section 5.

A third possibility is that the examiner – backed, if requested for review, by the BPAI – will decide that the claims of the parties do not correspond to the count, and that their applications are in fact for separate inventions. This is called "no interference in fact," which we code as both parties winning and do not include in our analysis of priority awards, below.[11] Each party would presumably prefer to be the sole winner in a priority case, as a finding of no-interference-in-fact limits the scope of both patents.

Finally, since 1984 the BPAI has made patent validity determinations in the course of an interference.[12] In some cases, the technology will be determined to be unpatentable to both parties. We code this as "both lose". Generally one party will lose on priority grounds, and the other on one of the standard reasons for patent invalidity such as prior art or failure to disclose best practice in the application.[13] The distribution

[9] Interferences where both parties have patents are rare, but also possible. They are litigated by federal district courts rather than the PTO.

[10] Linda: check out how this differs from a reexam requests based on alleged prior art.

[11] This category also includes split awards where it appears as if neither party's split includes the lion's share of value.

[12] 35 USCS sec. 135(a), PL 98-622 sec. 202, 98 Stat 3386 (1984).

[13] Material in an interference count is supposed to be patentable. See Lipscomb (1986), p. 342, 343.

of outcomes is shown in table 2.[14] Not surprisingly, a fairly common progression in these cases is that the party who anticipates losing on priority will try to claim no-interference-in-fact; if that doesn't work, he will introduce evidence challenging the validity of the other party's application or patent. Thus issues of both patent scope and patent validity are common grist for patent interference cases.[15]

2.4. Characteristics of interferences: sample statistics

Our sample is composed of 624 interferences that involve 1331 applicants: 624 senior parties and 707 junior parties.[16] We chose the cases to correspond to a random selection from the interference numbers assigned to patents declared between 1988 and 1994. We requested one-half of all the relevant numbers. Complete files were available for about 90% of the cases that we requested. Partial information on the remaining distributed cases suggest that our sample is representative of all the interferences declared in that period for technology that has at some point been incorporated in a patent.[17]

Tables 3 - 6 provide some information about characteristics of the interference cases.[18] The interference parties are heavily weighted towards domestic corporate inventors relative to all applicants for U.S. patents. The shares reflect Kingston's (2004) observation that interferences are more likely to arise in corporate research settings, as corporations would be more likely to set similar goals – in brief, to enter a well-identified patent race. The same observation appears to apply to university research. While the cell sizes are somewhat modest, our sample has a healthy representation of university applicants (over four percent compared to 1.4% in the population of patents at that time).

Even restricting the comparison to corporate patentees, those involved in interference cases are much larger, from a patenting standpoint, than the typical patenting

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[14] The share of "neither" may be too low by several percentage points due to non-distribution of such cases when they initially involve two applicants and no patent is ever awarded for the technology. See below for the discussion of the sample.

[15] This raises the fascinating question of whether the patent interference-type institution could substitute for that of a federal district court.

[16] Patent interference files become public (with the exception of settlement agreements) once all patent litigation involving the challenged applications is complete – the BPAI case, any federal appeals, and appeals to the Commissioner of Patents. If the challenged applications never mature to a patent, the cases are not made public, or, in the USPTO's terms, not distributed. The USPTO's File Information Unit provides access to these files on request. We are deeply indebted to the staff of the FIU for accommodating our hundreds of requests for files and for helping us obtain limited information available about the undistributed and unavailable files. Patent interferences are assigned a number when they are declared . With minor variations, the numbers are consecutive and chronological.

[17] Our sample statistics are also corroborated in the Calvert-Sofocleus studies and in those of Kingston's (2004) results that are based on the entire universe of interferences.

[18] The interference statistics reported here are drawn from the Interference Declarations and the Final Decisions or Final Judgements included in the Interference files at the FIU. We filled in some missing items about dates and parties from the PAIR database at the PTO web site. Information on patent portfolios and entity status is constructed from searching the PTO web. Where possible we matched the winning patent numbers to the NBER patent database and culled from there additional information about claims and citations. The comparison data on total applications (interfering and non-interfering) are generated from the NBER patent database and from USPTO sources. See Jaffe and Trajtenberg (2002)

corporation. Tables 4 and 4.5 present comparison data calculated from the NBER database.[19] Using any standard – mean portfolio, 75th, 90th, 95th percentile, controlling for technology class – our sample assignees are much larger than the population.

The research activities of junior and senior parties are largely commensurate for our sample. (see Tables 5 and 6) Overall, junior parties are somewhat larger than the senior parties, but the difference is not statistically significant, and does not hold across technology categories. The difference in mean patent portfolio size does not statistically vary by party either overall or controlling for technology class.

3. Patent Races

The patent race literature encompasses studies of how and when firms innovate in a dynamic, strategic context. We abstract from the subtleties of the theory and focus on its policy-relevant themes. In this section, we develop our key identification strategy: interference cases as indicators of strategic patent races.

3.1. Patent Races and Interference Cases

Patent races involve a group of firms all working to invent the same well-defined product.[20] Only the firm that achieves the invention first obtains the full value of the invention; the rest of the firms are losers. The more a firm invests, the more likely it is to win, either simply by virtue of investing more than other firms or, in the stochastic model, by enhancing the likelihood that it will achieve the goal within a given time period.

Because the patent system decrees that only one firm will be the winner, the firms impose negative externalities on each other. Each firm's investment decreases the likelihood that other firms will be first. The theory predicts that too many firms will be looking for the same product, that innovation will be faster (that is, the expected elapsed time until one of the firms finds the invention is shorter), and that aggregate research expenditures will be greater than is jointly optimal for the firms. If a firm takes into account what other firms are doing and actively tries to "beat" them (rather than merely ignoring the externalities it has imposed on the others), then the patent race turns into a contest ("strategic patent race"), which greatly exacerbates excess entry, speed and aggregate investment relative to a profit-maximizing consortium.

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[19] We matched 624 of the 725 distinct corporate assignees in our sample with the NBER code, and based the comparative portfolio statistics on NBER's calculations for these assignees and for the NBER population. We collected the portfolio numbers used in the remaining tables and in the probit analysis so that we could use a consistent procedure for all of the parties (corporate and non-corporate) in our sample. Discrepancies occur between our collection and the numbers generated for identical dates using the NBER data, but these do not appear biased in a single direction.

[20] The section attempts to provide some of the intuition behind patent races. Models have been developed that relax many of the constraints discussed here (e.g., the losers can get something; the value of the patent may not be fully known; there may be spillovers; losers can quit the race as soon as the winner is victorious, and indeed, even before the race begins). Our discussion relies heavily on Reinganum's (1989) definitive survey.

Such an intensified patent race would have a greater likelihood of yielding firms arriving at similar innovations within a short time span. Given the current U.S. patent system, some of these "duplicate innovations" should result in interference cases. Consequently, we argue that interference cases serve as an indicator of strategic patent races. We expect firms, industries, and technologies with a more frequent rate of interference to be those most engaged in tight patent races. Therefore, the distribution of firm, industry, and technology characteristics for interference cases, as a whole, may be indicative of the analogous distribution for strategic patent races. Furthermore, the distribution of the outcome of patent interference cases may reflect the distribution of outcomes for strategic patent races.

3.2. Drawbacks

Admittedly, our identification strategy is imperfect. Not all strategic patent races result in interference cases and not all interference cases are results of strategic patent races. The first issue is a concern insofar as there is a (unobserved) systematic selection of patent races into interference cases. For random selection, the distribution for interference cases can still accurately represent the distribution for strategic patent races. The main selection concern we have is that more contested patent races are more likely to lead to duplicate innovation and, thus, to interference cases. For this reason, we acknowledge that our study of interference case is most germane for the study of tight, contested patent races.

The second issue contributes to the noise surrounding our study. If interference cases result largely for reasons apart from strategic patent races, they will be a very noisy indicator of strategic patent races. We believe there are, primarily, three other processes that may account for the observed interference cases: random duplication, litigation abuse, and legal confusion.

3.2.1. *Random Duplication*

Random duplication refers to an unintended form of patent race. Firms, unaware of the research efforts of other competing firms, may still duplicate each other's innovation as their research draws from the same pool of potential innovations. Interference cases arising from such a process would be indicative of patent races but not strategic patent races. We would expect greater random duplication in industries and technologies where there are more firms involved in research per potential innovation. Using a fishing pond analogy, we expect to see different fishermen catching the same fish when there are many more fishermen at the pond and/or fewer varieties of fish. If random duplication is the main process generating interference cases, we should see interference cases concentrated in such industries and technologies.

3.2.2. *Abuse of Process*

Drawing from the literature on patent infringement litigation, we conjecture that patent interference cases may be used for purposes other than protecting intellectual property rights.[21] Abuse of the interference process appears harder, at least on the surface. Interferences are declared by patent examiners on the basis of filings presented by both parties that each has a *prima facie* argument for priority. The process may screen out more dubious cases.[22] However, firms do actively try to get into interference, calling the attention of examiners to potential cases, particularly those that involve an issued patent. A spurious interference is valuable to the instigator. First, it may delay issuance of a patent. Second, it imposes litigation costs on the other litigant, although these are estimated to be far less than for an infringement suit. Third, to avoid the delay and costs, the meritorious litigant might settle with the interferer, and agree to attractive licensing terms, technology sharing, or other fruits of extortion common to infringement settlements.

We consider infringement rates as a proxy for this kind of behavior. Lanjouw and Schankerman (2004) find a strong correlation between the probability that a patent is involved in infringement litigation and the characteristics of both the patent technology and the patent owners that make litigation attractive or unavoidable, including ease of settlement, litigation knowhow and the benefits of tying up competitors in litigation. These features carry over directly to the interference milieu, except, as discussed above, that litigants cannot choose to enter into interference. If the parties settle after entering into interference they are included in our data.[23] Infringement varies dramatically by technology category, with high rates found in drugs and electrical patents, and low rates in chemicals.[24] The electronics area in particular is considered a prime area for strategic litigation. To the extent that litigation abuse drives interference cases, we should expect to see interference vary in a similar fashion to infringement.

3.2.3. *Legal Confusion*

Patents in new areas of patenting – biotechnology and computers are subject to high rates of infringement litigation. The explanations for the rates draw on the theory of litigation: specifically, that litigants will find settlement more difficult when the legal regime is uncertain. In such cases it is easier for the parties to harbor divergent views of their likelihood of success, and hence less likely to see eye-to-eye on a deal that avoids

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[21] See Jaffe and Lerner (2004) and references there-in

[22] Something like an interference proceeding has been recommended as an alternative to infringement suits, for this and other reasons. See Jaffe and Lerner (2004), Hall etal., (2003), Kingston (1995). For a more view, see Lemley (2001). In many respects, interferences resemble *inter partes* reexaminations. An evaluation of interferences from this perspective is beyond the scope of this paper. In other work (still incomplete) we are comparing the value of using interferences versus infringement suits for determining patent validity and other non-priority claims.

[23] Lanjouw and Schenkerman find that the selection in infringements works before a case is filed. We instead anticipate selection in those cases that remain in interference until they are decided by a PBAI panel, but that the original declaration is not (less) influenced by these factors.

[24] Lanjouw and Schankerman (2001; forthcoming); Lanjouw and Lerner (2001).

litigation.[25] This implies that legal confusion may skew the distribution of interference cases toward cases involving new areas of patenting.

Even if ease of settlement is not an issue in interference declarations, the unsettled areas of patent law could be subject to greater interference rates due to confusion for the patent examiner. It may be unclear whether two parties have filed for separate or interfering patents, so that the examiner declares an interference to settle the extent of each parties' claims. If this explanation is correct, we would expect higher rates of interfering in biotechnology and computers. We would also be more likely to see outcomes that are not based on priority grounds.

3.3. Testing for Strategic Patent Races in Interference Cases

Each of the processes raised above imply a particular distribution of patent interference cases across industries and technologies. We use those implications, as well as another that is unique to strategic patent races, to examine our maintained assumption of interference cases as an indicator of strategic patent races.

Reinganum (1989) emphasizes the role of appropriability in how races proceed. When inventions are appropriable, or, in our context, patents are strong, an increase in the number of firms increases per firm investment in the "contest" form of a patent race. When patents are weak the reverse relationship holds. Putting the results together (with apologies to the authors who labored to be precise in their assumptions), we expect to find too many firms in all innovative industries with unrestricted entry and patents.[26] But if strategic racing is at play, we would expect to find interferences concentrated in industries with strong patent rights, as such industries are predicted to have greater per-firm spending and hence a higher likelihood of multiple invention within a short enough period of time to trigger an interference. Our primary test for the existence of strategic patent racing is whether applications in the strong technology categories are overrepresented among interference cases.

None of the other three processes suggest a link to patent strength. The infringement literature does not find litigation concentrated in strong patent industries, ruling out abuse of process as a possible explanation. Conventional wisdom does not suggest that the technologies with the most legal ambiguity, biotechnology and computers, are the ones with the strongest patents – ruling out legal confusion. Of the three alternatives, the process most likely to yield a similar strong patent implication is random duplication as strong patents may lead to more firms innovating in the area, leading to greater random duplication. However, this line of reasoning also suggests that the distribution of interferences would be proportional to the number of patent

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[25] Priest and Klein (1984).

[26] "Too many" is relative to a coordinated profit-maximizing effort by the firms, not social welfare. Entry should be tied to potential profits from innovation, which are not necessarily largest with either perfect or imperfect patents. Ideally we should control for number of firms in an industry as well as patent strength, but our data are nowhere near extensive enough to try both controls, so we assume in the present study that the size is uncorrelated to patent strength.

applications. In contrast, strategic patent racing suggests that, even after controlling for differences in patent applications, more interference cases arise in strong patent technology categories.

4. Rates of Interference and the Patent Race Hypothesis

To establish the connection between interference cases and strategic patent races, we turn to the rate of interference per patent application.[27] We seek to test whether interfering rates in different technology categories are correlated to patent strength, to the rates of infringement, or to the legal uncertainty surrounding patenting in the technology. If interferences result from random duplication in invention, we would expect the per-applicant rates to be equal across technologies.

4.1. Estimating the rate of interference

Calculating the likelihood that an application winds up in an interference from our data requires dealing with a truncation problem complicated by two issues: first, the rapid growth in the number of applications filed at the USPTO during the 1980s and early 1990s, and second, the concurrent changes in the shares of applications accounted for by each of the different (broad) technology classes. (see figures 1 and 2) We summarize here how our methodology handles truncation given the growth in total applications over time. We deal with the change in the distribution by technology by independently using this procedure for each technology. (see further details in the appendix)

Define the following terms:

A_t, $t = \{1, \ldots n\}$ is the number of applications filed in period t.

I_t, $t = \{1, \ldots n\}$ is the number of applications filed in period t that are involved in an interference at some later time (also called "interfered applications").

$D_{t,s}$, $s = \{0, \ldots, n\text{-}1\}$ is the number of interfered applications from period t that are declared in period $t + s$. All interferences are declared within n periods of the filing of the application.

$\alpha_{t,s}$ equals the share of interfered applications from period t that are declared in period $t+s$.

Thus:

$$D_{t,0} + D_{t,1} + \ldots + D_{t,n-1} = A_t;\ \ \alpha_{t,0} + \ldots + \alpha_{t,n-1} = 1;\ and\ \alpha_{t,s} I_t = D_{t,s}$$

Our calculations rely on two strong assumptions:

(1) The rate of interfering is constant, i.e., $I_t/A_t = r$ *for all* $t \ \varepsilon \ \{1, \ldots, n\}$. We are interesting in calculating r.[28]

[27] We restrict our attention to applications that mature to a patent.

[28] Our analysis abstracts from the possibility of patent office policy changes and exogenous changes in research activities. We are not proud of the assumption, but it allows an initial analysis. Our conclusions

(2) The distribution of declaration dates for interfered applications is identical for applications filed in each period, i.e., $\alpha_{t,s} = \alpha_{v,s} = \alpha_s$ *for all* $t, v \in \{1, \ldots , n\}$.

Our sample consists of all interferences declared during period *n*.

While all of the interfered applications involved in the interferences declared during period *n* were filed during periods $\{1, \ldots, n\}$, only a fraction of the interfered applications from periods $1, \ldots ,n$ are included in the interferences declared during period *n*: some of the interfered applications are in interferences declared prior to period *n* and some are in interferences declared after period *n*.

In period *n* we observe $\{ D_{1, n-1} ,\ D_{2, n-2} , \ldots , D_{n, 0} \}$.

Substituting from the above definitions:

$$D_{1, n-1} /A_1 + D_{2, n-2} /A_2 + \ldots + D_{n, 0} /A_n = \alpha_{n-1}I_1/A_1 + \alpha_{n-2}I_2/A_2 + \ldots + \alpha_0 I_n/A_n$$

$$= \alpha_{n-1}r + \alpha_{n-2}r + \ldots + \alpha_0 r = r$$

Hence, we can recover the rate of interference by summing the weighted interfered applications from each prior period that are in interferences declared during a single period, where the weights correspond to the inverse of the total number of applications filed during the same year as the interfered applications.[29] Rather than the actual values for $D_{t,s}$ we have a sample that is 43% of all the interferences filed in this period, and our estimates are accordingly inflated to account for the larger population of interferences.[30]

4.2. Interference rates and industrial research

The results are summarized in tables 7 and 8 (see Appendix Table 1 for details). We find that overall the likelihood that an application is involved in an interference in this period is from half to one-third the magnitude that it will be involved in infringement litigation. In the chemical and drug technologies, the likelihood is roughly equivalent or slightly higher, while in biotechnology we estmate the interference rate at twice the infringement rate: 5% of biotechnology applications enter into interference. If, as is

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rest on large differences among the rates, rather than subtle changes, which gives some credibility to the analysis even though the assumption is surely wrong to some degree. Surprisingly, Lanjouw and Schankerman find that litigation rates are constant for patents granted over a long period from the late 1970s through the 1980s, which perhaps lends some support to this analysis as well. See Lanjouw and Schankerman (2004).

[29] All of the interferences in our sample are for technology that matures to patents, so we use as weights the total number of applications filed during each year that mature to patents. This also avoids the difficulty of determining the share of patent applications that effectively duplicate an application filed earlier that was rejected or withdrawn. See Jaffe and Lerner.

[30] We dropped from the sample interference design patent cases (less than 1%) and cases whose declaration was accelerated to 1987 or delayed beyond 1993. The accelerated and delayed cases are included in the analysis in section 5.

argued earlier, interference represents the tip of a patent race iceberg, these estimates imply that a substantial number of patent races – and possibly substantial duplication of research effort – occurs in the biomedical and biotechnology fields.

4.2.1. *Strategic races versus random duplication*

We easily reject the hypothesis that the rates are equal in the different technology categories. The estimates of interference rates closely correlate to both estimates and conventional wisdom about when patents provide strong protection for intellectual property. Strongest protection accrues to chemical formulae – drugs and chemicals – while weak protection is afforded electrical technology and computers.

Table 7 gives the rate estimates by technology category, and Table 8 recalculates the rates relative to the overall rate for all technologies. Thus the rate for chemicals is 1.49 times greater than the average and drugs are interfered at over three times the average. Computers and electrical patents are interfered at only half the average rate. Breaking the drug category into smaller technology subcategories shows that, while the rates are high in all of the subcategories, they are highest for inventions that correspond to chemical formulae, and lower for medical equipment.

4.2.2 *Abusive litigation.*

The final two columns in tables 7 and 8 present estimates of the rate at which patents are involved in infringement litigation before the federal district courts (per 1000 patents) from two different sources. The estimate that incorporates data from the 1990s (second column) is nearly twice that of the first column, but both give very similar relative rates, shown in table 8.

The rates for drugs and for the drug categories are among the higher relative rates for both types of patent litigation. But the similarity stops there. Interference rates are high for chemicals, while in infringement suits, chemicals patents are litigated at only half the average rate. Alternatively, the computer and electrical rates are the lowest for all interferences, at about half the average rate, while the estimates for infringement place computer rates at well above average and electrical rates at 80 to 90 percent of the average. Within the drug category, we find high interference rates for actual chemical compositions – biotechnology drugs and other drugs -- and a lower rate for medical equipment (although it is still nearly twice the average). On the infringement side, medical equipment has the highest litigation rate, with biotechnology and other drugs closer to average.

4.2.3. *Unsettled law*

Our results give mixed results for the unsettled law hypothesis: the interference rate for biotechnology is very high, while that for computers is the lowest of all of our technology categories. The sample sizes (see Table 2) for both categories are small, but taken together they raise an interesting possibility. Our estimates suggest that unsettled law alone cannot drive priority litigation, unlike, perhaps, the situation in the federal district courts.

But our data suggest that unsettled law might at least contribute to interference litigation. For example, a prerequisite for a high rate might require that similar, if not identical technology is coming out of research programs - patent races with some independent components - but in addition the unsettled law means that a higher share of the races will result in declared interferences. Supporting this view is the high rate of non-priority determinations in both biotechnology and computers (see table 2). However, we caution against viewing these numbers as more than intriguing trends, as the cell sizes are small.

Overall, the table supports our identification strategy. High interference rates are found in technologies with strong effective patent rights; low interference rates characterize the industries with weak effective patent rights. One of the reasons that patent rights are strong is that they survive infringement litigation with relative certainty, which should lead to fewer infringement cases. Indeed, the infringement rates are reversed from the interference pattern: low in chemicals and standard pharmaceutical products, and high for computers and electrical patents. Thus, we do not find support for the hypotheses that either random invention or abusive litigation drive the interference rates. Finally, our estimates suggest that unsettled law may play a role in these rates, but more extensive data are necessary to determine how important the phenomenon may be.

5. Dynamic competition

Using observed interference cases as our empirical playground, we can investigate the nature of dynamic competition that spurs strategic patent races. The literature considers two components of technological change. The first is invention: who wins asymmetric patent races? The second is the question is who deploys the technology and how fast? This is usually referred to as “innovation” rather than “invention”. In this study we demonstrate the value of using the interference data in tests for patent race implications for innovation.[31]

A key hypothesis that emerges from the theoretical literature on innovation is that challengers will move with all possible speed to start marketing the new product, but incumbents are conflicted. Incumbents have a product on the market, and might prefer to delay introduction costs for the new good, reducing the losses incurred from cannibalizing revenue from the current product.

The patent system is expected to make incumbents even more bashful relative to challengers. Once a firm has a patent, it need not worry about introducing the product to preempt loss of sales to a competitor. While patent races are expected to sometimes advantage incumbent firms, and under other conditions challengers, in both cases the results refer to a race to obtain a patent, not a race to actually innovate. In cases where

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[31] We address more fully dynamic competition issues, including hypotheses relating to who invents first, in a subsequent paper. Cohen and Ishii (unfinished).

the challenger firms are more research intensive we can predict with confidence that they will actually innovate. For the reverse cases we can posit that incumbents will speed up the invention time, but not the innovation time.

The U.S. patent system, with its first-to-invent priority structure, means that prospective innovators can start to slow down even before they get a patent. Once a firm has invented a product, it can delay filing – within reason, and possibly with penalty, discussed below – knowing that if someone else files, the firm can then file its application and prevail in an interference.[32] The advantage from this maneuver is three-fold: first, the patenting expenses are delayed until the firm is ready to market its invention. Second, delaying filing and patent issuance deprives competitors of the information that an application divulges about the invention Finally, the limited patent term is scheduled when most valuable: when the product is actually sold rather than in part when the product is being readied for sale.

Delaying a patent until the firm is ready to market is an attractive strategy for any firm. The patent race literature identifies marketing time as later (or at least not sooner) for large firms than small firms. Intensifying the theoretical result is the fact that small firms may not be able to delay filing. Small firms, particularly start-ups, rely on their patent portfolio for financing. In cases where development and marketing are undertaken by entities other than the inventor, patents are critical to commercialization. Universities, startups, government agencies and in general small firms are less likely to employ a filing-delay strategy than are large corporations. Thus, confirmation of this hypothesis will in part support the patent race literature and in part reflect a separate bias conferred by the patent priority standards in the United States against small firms.

We propose the following hypothesis: when incumbent firms are the second-to-file in an interference case, they are more likely to be playing a strategic filing-delay game and have invented earlier, and thus are more likely to win the interference (*ceteris paribus)*. As with the existence of races discussed above in part A, the interference cases will measure only the tip of the iceberg, or where firms are delaying and then have to scramble their application to respond to the filing of a competing inventor. Observing the pattern of disproportionate success to incumbent that are second-to-file suggests that there may be considerable ice beneath the surface.

Size and incumbency are likely related (for a start, they are closely related in our measurements below), but their impact on interference outcomes may differ. Supporters of the U.S. first-to-invent standard claim that small firms and individual inventors need and take more time between inventing and filing because of their lack of facility with the patent filing process. Such firms and entities should not be penalized for lacking sophisticated legal divisions; rather we can encourage their inventive efforts by allowing them to interact with patent bureaucracy only after they have successfully come up with a

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[32] Firms need to show that they moved along with reasonable diligence. If it is proved that they concealed or suppressed an invention they may lose priority, and abandoning an effort mid-stream can result in the loss of an early benefit date. The legal standards leave a lot of room for interpretation (and litigation). See Lipscomb, p. 363.

patentable invention. This hypothesis runs directly counter to the discussion above about the possible advantages given to large firms by the patent system since they have the option – based on liquidity – to delay filing. If the first effect dominates, small firms should win interferences and in the second case large firms should prevail.

5.1. An empirical model

We assume that the BPAI is accurate in its assessment, and that settling parties correctly anticipate its ruling; specifically, that the party who wins the case is likely to be the first inventor. When the junior party wins the case, the second-to-file was probably the first-to-invent. This means that the inventor is not innovating with all possible speed. Indeed, had he reduced his invention to practice and filed promptly for a patent, he would have been the senior party. For all we know, had the senior party not filed an application, the junior party might have delayed innovation even longer. Alternatively, if the junior party loses (i.e., the senior party wins) then there is no evidence that either party delayed innovation. The junior party is second-to-file, but also second-to-invent.[33]

Consider the following stylized patent filing process. Let *A* and *B* be two inventors who invent the same technology at times *a* and *b* and file at times *f* and *g*. We assume that $f < g$, so that *A* is the senior party. For each party, the discrepancy between inventing and filing depends on a common technology factor, *T*, that measures the average difficulty in reducing the invention to practice and preparing a patent application for the technology, a set of characteristics of the inventors, strategic choices, and institutional variables:

$$(5.1) \quad f = a + T + \gamma 1_A X1_A + \varepsilon_A$$
$$g = b + T + \gamma 1_B X1_B + \varepsilon_B$$

The BPAI assigns legal invention dates α and β to *A* and *B* which are based on admissable evidence and may vary systematically from the actual invention date depending on characteristics of the inventors (e.g., if the inventor is foreign) and other institutional features:

$$(5.2) \quad \alpha = a + \gamma 2_A X2_A + \theta_A$$
$$\beta = b + \gamma 2_A X2_B + \theta_B$$

Rearranging,

$$(5.3) \quad \alpha - \beta = (f - g) + \gamma_A X_A - \gamma_B X_B + (\varepsilon_A - \varepsilon_B + \theta_A - \theta_B)$$

where $\gamma_A = (\gamma 1_A, \gamma 2_A)$ and γ_B, X_A, and X_B are defined similarly. We assume that the error terms are iid so that their consolidation in equation (5.3) yields a valid estimation.

[33] Of course, both parties may have delayed innovation, but we cannot distinguish this outcome in the interference data.

If the junior party wins the interference, his legal invention date, β, will be earlier that the legal invention date α for the senior party, or $a > \beta$. The expression in *(5.3)* thus constitutes a latent variable in the following probit estimate[34]:

$$(5.4) \quad Prob\{ Y > 0 \mid Y = \alpha - \beta \ = (f - g) + \gamma_A X_A - \gamma_B X_B + \xi \}$$

Our dependent variable is whether or not the junior party wins the interference. If a junior party is more likely to win under certain circumstances – for example, if he is an incumbent firm – then we conclude that incumbent firms take longer to innovate than challengers.

The main objective of this estimation is to see whether incumbent firms tend to be in the position of first-to-invent and second-to-file, which the patent race theory suggests would result from a strategic decision to delay innovation. As the discussion in section 2 explains, a number of case and party characteristics are likely to influence the outcome of a priority dispute. We consider variables that correspond to our hypotheses, and then possible controls for institutional features, bureaucratic components and technological components.

5.1.1. *Size and strategy*

In line with the discussion above, we wish to test separately for size and incumbency. If the claim about dilatory small parties or generally-advantaged large firms is correct, then small (large) parties should be disproportionately successful. A small party, even as junior party, is likely to have invented first relative to larger firms who move to file with dispatch, with similar reasoning for large parties. They will be disproportionately successful as both junior party and senior party, and for every benefit basis, unless their opponent is someone who, for any reason, also delays filing..

We use the patent portfolio data for each applicant at the time the interference is declared as a proxy for size. We adjust the portfolios to reflect average portfolio rates within all assignees who patent the technology category (see table 4.5) and further adjust the portfolios to have a mean of one. We also consider two alternative size specification. The first is for firms who claim "small entity status" in their patent filings versus "large entity status". Entity status is based on the Small Business Administration employee-based measure; firms that qualify are eligible for reduced filing fees.[35] The second is for individual inventors versus applications assigned to corporations or governments.

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[34] Due to the restrictions on the variance of the error term in the probit model, in the following estimations we estimate a coefficient for $(f - g)$. The coefficients for the variables of interest, X, are thus the ratio of the estimated coefficients for X and the estimated coefficient for the variable measuring the difference in filing dates. However, the marginal effect of the variables X are unaffected by the inclusion of an estimatedcoefficient for $(f - g)$.

[35] Non-profit institutions, including universities, have inconsistent entity status, depending on what they plan to do with the patent in question. They are included in the "large" category. In estimations not reported here we tested whether they had any advantage in an interference, but found no systematic effects.

In general we can only test for the dominating factor among the two size hypotheses. Perhaps both small and large firms delay. We attempt a discriminatory test by including both the continuous size variable and the discrete measure in an estimation below. This is admittedly a poor test, valid only if only the large effect is a threshold matter (e.g., once a firm obtains a given size and patent portfolio is will be both litigation savvy and have access to credit; alternatively, the smaller a firm is the more likely to will be to have filing problems).

The strategic argument implies that incumbent firms should be disproportionately successful relative to challengers because they hold off filing for a patent even when they have an invention in hand. The junior party is potentially an incumbent in cases "for" the junior party, that is, when either the senior party has a patent or both parties are applicants. We assume that potential incumbents are more likely to be actual incumbents if they are large. Thus our incumbency index is a product of the technology-adjusted patent portfolio size for the firm and a dummy variable indicating when the case is "for" the junior party.

5.1.2. *Institutional features*

Institutionally, the junior party has the burden of proof, and hence is at a disadvantage in all of these cases. A further burden is imposed on the junior party if his application was filed after the senior party's patent is issued; however, our data are currently too sparse to control for this problem. The other key institutional control for this dataset is whether the firms are domestic or foreign. During this period certain kinds of priority evidence had to be based on activities in the United States, so that foreign firms were formally disadvantaged in their attempts to establish first inventorship.[36]

5.1.3. *Bureaucratic controls*

We include a control for when the senior party has a patent in interference. While no formal advantage is given to patented status, an adverse decision in an interference will reverse a previous ruling of the USPTO, so that bureaucratic reluctance to admit error might confer an advantage on the patentee in these cases. Alternatively, when the junior party holds a patent, and simultaneously the designation of junior party, the USPTO has already conceded a possible error, so we do not expect a symmetric advantage to hold for junior parties.

5.1.4. *Technological controls*

We include controls for each of the broad technology areas. We also include variables that measure the number of citations in the patent that wins the interference. Citations in a patent relate the patent to previous technology and delineate the extent of

[36] This situation was changed in 1996, but the discriminatory clauses remained in effect for evidence about inventions that pre-dated the change, which includes all of the cases in our sample. We tested for whether the decision boards ruled more favorably towards foreign firms after the policy change, but found no statistical support for a change.

the patent-holders' rights. In patent prosecution, inventors and patent examiners typically haggle over inclusion of citations, as the inventor would in general prefer fewer citations. However, examiners win these disputes. Thus, citations are not a choice variable for inventors, but rather provide a measure of the extent to which a patent derives from previous inventions (many citations) or is a less derivative work.

We expect the number of citations to have be negatively correlated to the likelihood that a junior party wins the interference. The optimal method to reduce an invention to practice and prepare an application is more likely to be known to both inventors for a highly-citing patent, as the underlying technology for such patents are well-understood. Consequently, there is no (good) reason for the elapsed time between invention dates and filing dates to differ between the parties. Alternatively, the elapsed time for a patent with few citations could easily differ between two inventors, as one might pursue more dead-ends than the other. Dead-end options have an asymmetric effect on interference outcomes relative to the well-worn development path for derivative patents. In some cases, the junior party will be the unlucky wanderer, but, if first-inventor, will prevail in the interference. On the other hand, if the senior party pursues the dead-ends, but still manages to be senior party, the resolution will be the same as for more derivative patents.

Similarly, the included dummy variables for technology classes allow application-preparation and patent value to differ by technology. Patenting in new areas (computers, biotechnology) might be more subject to differential delays than in more established areas. If patents in some technology classes are systematically more valuable than others, firms may uniformly hustle to prepare their inventions for patenting, so that the elapsed time between invention and filing is uniform and senior parties deserving of their filing status.

5.2. Who innovates first: results

The results confirm the existence of strategic delay by incumbents in each of the specifications. The incumbency effect is positive in all specifications. A Wald test for significance of the ratio of the coefficient for incumbency to the coefficient for the difference in filing dates is .06 and .07 for the first and second specifications in Table 10. For the third specification (and the probit estimations reported in Table 9), the relevant test is the ratio of the sum of the coefficients for incumbency and Junior Party portfolio size to the coefficient for the difference in filing dates. This yields a chi-square statistic significant at 11%. A standard deviation increase in the size of the junior party's patent portfolio is associated with a seven to nine percent increase in its likelihood of success under the conditions where we expect the party to be an incumbent firm.

The estimates reported in Table 9 provides no support for the small inventor filing disadvantage or large firm litigation advantage, although they may cancel each other out. Junior parties are not more likely to prevail when they are small by any of our measures. Neither are large firms, except in the incumbency case identified above. When two measures of size are included (Table 9, third specification) we obtain no additional enlightenment. Note that the magnitude of the coefficients is small for all of the variables that attempt to measure firm size.

The results also reveal some interesting characteristics of the interferences. When the senior party has a patent, his chance for success increases by 12%, even though the formal burden of proof is identical in these cases to the all-applicant alternative.

The BPAI does support junior party patentees when their opponent bases his claim on a foreign patent, as is the case in a significant fraction of the cases where the junior party has a patent. Here, the junior party obtains a net benefit of about 15% by virtue of his opponent. A senior party patentee going up against a foreign junior party is in great shape: the combination of a patent and a foreign opponent increases his chance of success by 36%. Worst off are junior parties who are not only foreign but also defending a foreign benefit date. These parties have a disadvantage of around 25%. Overall, foreign parties are deeply disadvantaged in these cases. Whether the new regulations are more equitable is an important area for study.

Finally, while none of the technology categories are distinguished in the estimate, the citation measure makes a difference: each subtracted citation makes it a half percent more likely that the junior party will win. A standard deviation decrease in patent citations increases the likelihood that the junior party wins by 5%. Thus, it appears that inventors and filers are likely to diverge – and inventors file second – for less derivative inventions.

6. Conclusions.

This study provides support for two hypotheses: first, that in general patent interference cases result from strategic patent races, and second, that the outcomes of the interference cases support some predictions from the theoretical race literature about dynamic competition. We find that interferences are much more common in the technology categories where patent rights are strong. Furthermore, we find evidence that suggests that incumbent firms have an incentive to delay innovation.

The results raise some important questions about industrial research and the U.S. patent system. If patent races are common – and our results suggest that in certain technology categories they may be pervasive – then the investment in research may be inefficient. The argument for the need for strong patent rights to support expensive research can be turned upside-down: rather, the results suggest that in some fields strong patent rights induce, rather than support expensive research, and not necessarily with an increase in research productivity. The race potential should be joined to the patent-strength debate. Our results suggest that the welfare effect of strong patent rights may be undesirable.

This study offers some preliminary conclusions about how the first-to-invent and first-to-file patent systems differ in priority grants. Like other critics, we do not find evidence that the system works to the benefit of small inventors or firms. If we assume that the winner of an interference is the first-to-invent, the results suggest that small inventors do not suffer from a filing disability. Alternatively, there is some indication that other groups do have such problems – the U.S. government , for example, is far more likely to enter our sample as junior party, yet wins a reasonable share of cases, which suggests that both institutions systematically take longer to file patent applications than do private firms and individuals. However, we need more data to establish the trend statistically. Similarly universities are twice as likely to be junior parties as senior parties, but they too are scarce in our sample.

A troubling consequence of the first-to-invent system is that it doesn't penalize firms that are slow to file, as long as they are not too slow. Instead of being used by worthy small inventors, our data suggests that the system supports strategic incumbents who wish to defer filing for a patent, and perhaps defer innovation as well.

Alternatively, our study suggests a separate benefit to the first-to-invent structure. Assuming we prefer to reward inventors with a patent, rather than speedy filers, our study suggests that first-to-file will make more mistakes on inventions that are more innovative. In consequence, the first-to-invent system may in fact provide better incentives for fundamental invention than a first-to-file system.

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Table 1: Types of Interference Cases					
		Case Type			
		All Applicant	SP Patentee	JP Patentee	Total
Senior Party:					
Interfered Patent		0	132	0	132
Interfered Application					
	Application Only	62	0	31	93
	Foreign Patent	80	0	218	298
	Parent Patent	28	0	72	100
(First) Junior Party:					
Interfered Patent		0	5	317	322
Interfered Application					
	Application Only	95	65	0	160
	Foreign Patent	52	34	1	87
	Parent Patent	23	28	2	53
Total		170	132	320	622
Share		27.33%	21.22%	51.45%	

Table 2

Table 2: Distribution of Outcomes by Technology Category, number and share					
Chemicals	104	58	18	8	188
	55.32%	30.85%	9.57%	4.26%	
Communications & Computers	19	7	2	2	30
	63.33%	23.33%	6.67%	6.67%	
Drugs - total	93	43	16	6	158
	58.86%	27.22%	10.13%	3.80%	
Biotech	21	16	7	0	44
	47.73%	36.36%	15.91%	0.00%	
Med Equip	22	3	1	4	30
	73.33%	10.00%	3.33%	13.33%	
Drugs-other	50	24	8	2	84
	59.52%	28.57%	9.52%	2.38%	
Electrical	41	14	5	1	61
	67.21%	22.95%	8.20%	1.64%	
Mechanical	59	29	5	7	100
	59.00%	29.00%	5.00%	7.00%	
Other	48	21	3	12	84
	57.14%	25.00%	3.57%	14.29%	
	Senior Party	Junior Party	Both	None	Total
Total	364	172	49	36	621
	58.62%	27.70%	7.89%	5.80%	

Table 3

Table 3: Sample applicants relative to all applicants, 1977 - 1993			
	Sample frequency	Sample percent	Population percent
US Corp.	724	56.61%	41.41%
Foreign Corp.	344	26.90%	36.79%
US Indiv.	93	7.27%	13.50%
University	55	4.30%	1.40%
Foreign Indiv.	30	2.35%	5.07%
U.S. Govt.	14	1.09%	1.34%
Foreign Govt, NP	19	1.49%	0.48%

sources for Population Percents:
http://www.uspto.gov/web/offices/ac/ido/oeip/taf/h_at.htm#parta2_1b
http://www.uspto.gov/web/offices/ac/ido/oeip/taf/univ/univ_toc.htm

Table 4: 1976-1999 Assignee Patent Portfolios: Sample versus Population (NBER data, assigned patents only)		
	Sample (644 matched assignees)	"Population" (147,941 assignees)
Mean	906.35	11.44
Median	110	1
Std Dev	2315.85	187.18
Min	1	1
Max	22011	22011
Q75	624	3
Q90	2302	9
Q99	11882	119

Table 4.5: 1991 Patent Portfolios: Comparison of Sample Assignees and All Assignees by Technolocy Category (NBER Data; assigned patents only)						
	All Assignees in NBER database			Sample Assignees		
Technology Category	N	Mean Patents Within Category	Mean Portfolio, at least one patent in category	N	Mean Patents Within Category	Mean Portfolio, at least one patent in category
Chemicals	20887	10.881	35.037	456	231.857	709.048
Communication/ Computers	8980	9.747	65.419	263	155.099	1110.67
Drugs	8525	7.236	58.821	338	75.355	838.941
Electrical	18815	9.01	38.193	367	175.398	864.787
Mechanical	33489	6.289	2999	423	134.225	757.355
Other	38746	4.24	20.461	443	73.334	728.14

Table 5: Per-case Mean Patent Portfolio at Declaration by Technology Category and Party			
	Junior Party	Senior Party	All
Chemicals	1,636	1,704	1,669
Computers	1,331	2,726	2,005
Drugs	647	559	607
Electrical	2,140	1,416	1,795
Mechanical	731	467	603
Other	535	470	504
Total	1,108	1,069	1,089

Table 6: Mean Patent Portfolio by Party and Case Type (sd in parentheses)			
type of case:	Junior Party	Senior Party	Freq.
All Applicant	1103 (1963)	1087 (2030)	170
JP Patentee	1265 (2210)	1199 (2282)	321
SP Patentee	910 (2138)	692 (1482)	131
Total	1147 (2132)	1061 (2075)	622

Table 7

Table 7: Interference and Infringement Rates by Technology Category (cases per thousand)			
	Interference Rates	Infringement Rates	
		[1]	[2]
All	**6.26**	10.7	19
Chemicals	**9.15**	5.4	11.8
Computers	**2.95**		25.6
Drugs	**21.49**	20.1	
Electrical	**3.44**	9.6	15.4
Mechanical	**4.25**	11.8	16.9
Other	**3.93**	15.2	34.2
Biotech	**47.11**		27.9
Med Equip	**11.58**		34.6
Drugs-other	**21.24**		22.2

(1) total for patent granted 1980 - 1984, Table 1, Lanjouw & Schankerman (2001).
(2) total for patents granted 1978- 1995, Table 1, Lanjouw & Schankerman (2004).

Table 8: Relative Interference and Infringement Rates by Technology Category (All = 1.00)			
	Interference Rates	Infringement Rates	
		[1]	[2]
All	1.00	1	1.00
Chemicals	1.46	0.50	0.62
Computers	0.47		1.35
Drugs	3.43	1.88	
Electrical	0.55	0.90	0.81
Mechanical	0.68	1.10	0.89
Other	0.63	1.42	1.80
Biotech	7.53		1.47
Med Equip	1.85		1.82
Drugs-other	3.39		1.17

Table 8.5: Sample Statistics					
Variable	Obs	Mean/ *Share	Std. Dev	. Min	Max
JP win*	536	0.32		0.00	1.00
difference in filing dates in years	536	-0.94	1.16	0.00	-10.47
JP incumbent (cases "for" JP)	262	0.81	1.81	0.00	13.45
Backward citations	530	10.20	9.82	0.00	56.00
JP patentee*	535	0.51		0.00	1.00
SP patentee*	536	0.21		0.00	1.00
SP foreign*	536	0.34		0.00	1.00
SP benefit foreign*	536	0.53		0.00	1.00
JP foreign*	536	0.26		0.00	1.00
JP benefit foreign*	536	0.20		0.00	1.00
JP inventor*	536	0.11			
SP inventor*	536	0.11			
JP small entity status*	536	0.16		0.00	1.00
SP small entity status*	536	0.14		0.00	1.00
JP patent portfolio (tech adjusted)	535	1.00	2.00	0.00	13.93
SP patent portfolio (tech adjusted)	535	1.00	1.95	0.00	13.45

Table 9: Probit results - probability that Junior Party wins in priority suit

y = JP win	Coeff	Std. Err	dF/dx	Coeff	Std. Err	dF/dx
difference in filing dates	0.216	0.063	0.075	0.214	0.064	0.075
JP incumbent	0.138	0.067	0.048	0.142	0.066	0.049
Backward citations	-0.016	0.007	-0.006	-0.015	0.007	-0.005
JP foreign*	-0.531	0.153	-0.170	-0.521	0.152	-0.167
JP benefit foreign*	-0.278	0.161	-0.092	-0.265	0.160	-0.088
SP foreign*	-0.025	0.143	-0.009	-0.016	0.142	-0.005
SP benefit foreign*	0.476	0.147	0.163	0.453	0.145	0.155
JP patentee*	0.011	0.161	0.004	-0.004	0.158	-0.001
SP patentee*	-0.357	0.187	-0.116	-0.367	0.181	-0.120
JP patent portfolio (tech adj)	-0.043	0.045	-0.015	-0.050	0.045	-0.017
SP patent portfolio (tech adj)	0.056	0.031	0.019	0.053	0.030	0.019
chemicals*	-0.009	0.209	-0.003			
elect./comm./comp.*	-0.258	0.235	-0.085			
drugs*	-0.014	0.217	-0.005			
mechanical*	0.138	0.226	0.049			
constant	-0.181	0.243		-0.191	0.160	
Number of obs	528					
obs. P			0.318			0.318
pred. P			0.299			0.300
Prob > chi2	0.000					
Log likelihood	-299.227			-300.972		

(*) dF/dx is for discrete change of dummy variable from 0 to 1

Table 10: Probit results - probability that Junior Party wins in priority suit, alternate size specifications						
y = JP win	dF/dx	Std. Err.	dF/dx	Std Err.	dF/dx	Std. Err.
difference in filing dates	0.077	0.022	0.075	0.022	0.075	0.022
JP incumbent	0.038	0.018	0.039	0.018	0.050	0.023
Backward citations	-0.006	0.002	-0.005	0.002	-0.005	0.002
JP foreign*	-0.163	0.045	-0.155	0.045	-0.164	0.044
JP benefit foreign*	-0.090	0.050	-0.090	0.050	-0.086	0.050
SP foreign*	-0.018	0.050	0.001	0.050	-0.001	0.049
SP benefit foreign*	0.165	0.049	0.159	0.049	0.159	0.049
JP patentee*	-0.015	0.053	-0.009	0.053	0.000	0.055
SP patentee*	-0.122	0.055	-0.118	0.055	-0.117	0.055
JP patent portfolio (tech adj.)					-0.016	0.015
SP patent portfolio (tech adj.)					0.020	0.011
JP inventor	0.004	0.068				
SP inventor	-0.077	0.062				
JP small entity status			0.055	0.062	0.055	0.063
SP small entity status			0.001	0.064	0.012	0.065
Number of obs	528		528		528	
obs. P	0.318		0.318		0.318	
pred. P	0.301		0.301		0.300	
Prob > chi2	0		0		0.000	
Log likelihood	-302.205		-302.454		-300.494	
(*) dF/dx is for discrete change of dummy variable from 0 to 1						

Applications that mature to patents by technology category

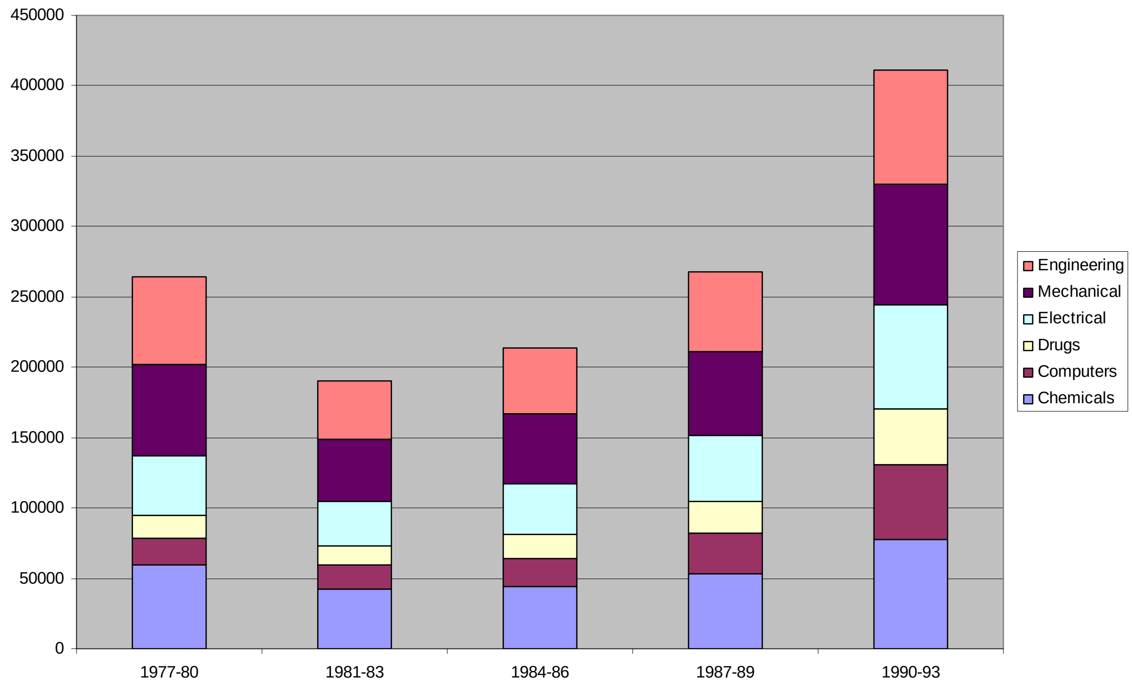
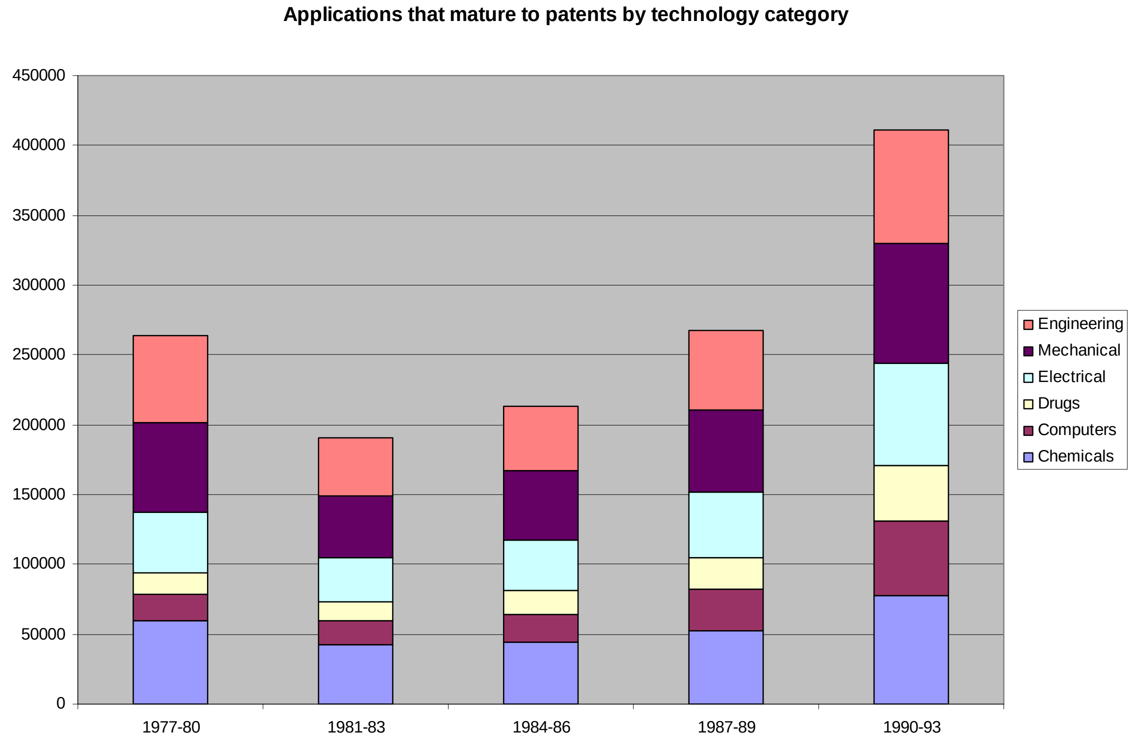


Figure2


Applications that mature to patents by technology category
450000
400000
350000
300000
250000
200000
150000
100000
50000
0
1977-80
1981-83
1984-86
1987-89
1990-93
Engineering
Mechanical
Electrical
Drugs
Computers
Chemicals

Appendix Table: Data for calculating interfering rates										
	Chemicals	Computers	Drugs	Electrical	Mechanical	Other	All	Biotech	Med Equip	Drugs-other
Number of Interfered Applications from cohort years in Interferences Declared 1988 - 1993										
76-78	4		6	1	6	5	22			6
79-81	20	1	15	1	8	6	51	7	2	6
82-84	81	12	76	24	25	27	245	20	15	41
85-87	150	24	143	40	64	65	486	45	24	74
88-90	113	21	91	54	90	65	434	26	17	48
91-93	11	4	7	5	12	8	47		5	2
Total number of Applications in Cohort Years that mature to a patent										
76-78	44,990	12,867	11,202	31,355	49,550	47,439	197,403	1,096	3,302	6,804
79-81	44,210	15,447	12,650	32,357	46,924	44,557	196,145	1,534	3,858	7,258
82-84	42,314	17,697	14,021	32,762	44,536	42,349	193,679	1,963	4,410	7,648
85-87	45,856	22,305	18,818	38,920	52,448	49,693	228,040	2,499	6,402	9,917
88-90	55,852	32,407	24,689	50,326	62,812	59,529	285,616	3,198	8,754	12,737
91-93	58,172	41,973	30,779	55,779	64,337	61,198	312,241	5,004	11,452	14,323
rate of interference for sample per thousand	3.97	1.28	9.33	1.49	1.85	1.70	2.72	20.44	5.02	9.22
estimated rate of interference; inflating from 43.4% sample	**9.15**	**2.95**	**21.49**	**3.44**	**4.25**	**3.93**	**6.26**	**47.11**	**11.58**	**21.24**

Notes for Appendix Table: The sample includes six years of interference declarations which are broken into two 3-year periods to better capture the changes in the number of applications per category over time. This gives 2 estimates of the rate, one based on the 1988-1990 period and the second for the 1991-1993 period. The rates are supposed to be identical, and they are pretty close. We combine the two, using all of the data in the appendix table, which gives twice the relevant rates, so that the calculated rate for each technology (column) is obtained by as follows:

rate (for each column) $= \frac{1}{2}(\sum_{t,s}(D_{ts}/A_{ts}))$, where D_{ts} are the entries in the top part of the matrix and A_{ts} in the lower part.