Determinants of Opposition against EPO Patent Grants – The Case of Biotechnology and Pharmaceuticals*

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Abstract
We analyze the determinants of opposition to biotechnology and pharmaceutical patents granted by the European Patent Office (EPO) between 1978 and 1996. Opposition at the EPO is the most important mechanism by which the validity of a European patent can be challenged. In our sample, 8.6 percent of the patents are attacked in opposition proceedings. We show empirically that the likelihood of opposition increases with patent value, and that opposition is particularly frequent in areas with strong patenting activity and with high technical or market uncertainty. We comment on the implications of these results for the design of the patent and litigation system.

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1 INTRODUCTION

Intellectual property rights constitute an important aspect of public policies trying to enhance the incentives for innovation. Patent systems frequently form the core of such policies, and appropriately, they have found considerable attention in the industrial economics literature on innovation.[1] Yet, among others two important aspects of patent rights still require considerable attention. First, patents endow their holders with *passive* rights. A patent holder may have to undertake substantial efforts to defend his patent against either a validity challenge or against infringement of the patent right. The efficacy of the legal mechanisms by which patents can be defended may have considerable impact on R&D and innovation incentives. Even the most comprehensive patent system cannot work well if the rights allocated to patent holders cannot be enforced or defended in court, or if the enforcement or defense is too costly. Second, some attacks on the validity of patents should clearly succeed. The patent system itself is not a flawless mechanism. Just as legal decisions in courts may be subject to erroneous decision-making, some decisions made by the staff of patent offices may be flawed. For example, some evidence on prior art may in principle be available and relevant for the examination of the patent's degree of novelty. But a relevant document may have been overlooked or have been out of the immediate reach of the examiner. The information may surface only after the patent has been granted. Other errors may occur in the translation processes at supranational institutions, yielding patent rights that have an unintentionally broad scope. The examination of patent rights can be interpreted as a process in which the breadth and scope of the patent right is carefully designed to achieve an optimal tradeoff between R&D incentives and losses of static welfare due to the exclusion of competitors. Therefore, errors in the examination of patent applications can have serious welfare consequences.

The post-grant opposition mechanism at the European Patent Office is of interest with respect to both questions. Though substantially different from related U.S. legal mechanisms by procedural standards[2], the *effects* of an opposition resemble those of a centralized "validity suit" at the European level where opponents may argue that a patent granted by the EPO should be either revoked or amended. The opposition process can be initiated by any third party. Consequently, the process allows opponents to threaten the position of a patent holder and may therefore undermine R&D incentives. At the same time, since it is frequently initiated by competitors of the patent holder, the opponents may be able to generate information about the appropriate specification of

[1] For recent theoretical contributions to the analysis of patent systems see Merges and Nelson (1990) and Scotchmer (1991, 1996) . A survey of patents as economic indicators is provided by Griliches (1990).

[2] An opposition proceeding does not exist in the U.S. juridical system where challenges to the validity of a patent are dealt with in civil courts. Since the costs of such suits are much higher than those for opposition, validity suits in the U.S. are far less frequent than opposition cases at the EPO. See Lanjouw and Schankerman (2001) for estimates of the frequency of validity suits in the U.S.. See section 2.4 of this paper for a comprehensive description of the European opposition procedure.

the patent which has not been available to the patent office's examiner and in this way enable the correction of erroneous granting decisions.

From an industrial economist's perspective, the European opposition procedure is a central legal institution affecting the economic efficiency and efficacy of the European Patent Convention (EPC) – the supranational European patent law under which more than 1.3 million international patents have been applied for between 1978 and 2001, thus qualifying as the most important patent jurisdiction in Europe. Consequently, knowledge about EPO oppositions is crucial to determine the optimal trade-off between setting *ex ante* incentives for innovation and allowing for *ex post* corrections of erroneously specified patent rights in one of the world's most important high technology industrial clusters.

However, despite its obvious importance – on average, 8.2 percent of the patents granted by the EPO are subject to opposition[3] – the economics of this institution are virtually unknown, and there have been no studies analyzing it in detail. To the best of our knowledge, this paper is the first study to put forth an econometric study of the determinants of opposition at the European Patent Office.[4] Due to the similarity in the effects of European oppositions and US validity suits we therefore see this paper as a counterpart to recent U.S. studies which have focused on patent litigation.[5] Due to the distinctive features of the two legal institutions the results of the latter studies cannot easily be transferred to the European context, since legal mechanisms and institutions differ considerably. Thus, there is a double motivation for undertaking a study the European institutions, and in particular of the opposition procedure.

But an analysis of post-grant opposition is not only relevant in the context of *European* patent law – the institution *per se* is of some interest for policy-makers in other jurisdictions, since it may offer a relatively efficient solution to a number of problems. Uncertainty about the validity and scope of patent rights can have considerable negative implications. Firms may delay investments if they expect another firm to enter a market under patent protection. But the patent holder himself may also delay the exploitation of a patent if the extent of legal protection against imitators is unclear. Moreover, in the case of objectively erroneous decisions by a patent office, a fast and

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3 This is computed from the number of opposition cases filed against patent grants of applications filed between 1978 and 1992. For data sources, see section 4 of the paper.

4 Van der Drift (1989) is the only earlier study we are aware of in which opposition data are used to classify patents according to their importance. But the determinants leading to opposition are not studied in that paper. The role of opposition as a predictor of patent value is emphasized in Harhoff, Scherer and Vopel (2003). Their study shows that patents that survived opposition are on average ten times more valuable than comparable patents which were not attacked, but they do not analyze which patents are selected for opposition.

5 See Lanjouw and Schankerman (2001) for an exploration of the determinants of patent litigation in the U.S., and Lanjouw and Lerner (1998) for a survey of the empirical literature.

inexpensive resolution of the legal disputes could improve economic welfare.[6] Merges (1999) has recently argued that an inclusion of post-grant opposition may improve the efficiency of the U.S. patent system. He explicitly refers to the recent onslaught of patent grants protecting business models and software in the U.S. The re-examination procedure in the U.S. patent system does not appear to be an attractive early-stage litigation mechanism, and litigation in U.S. courts is costly and time-consuming. To correct possible errors made by the patent office relatively soon after the patent has been granted, Merges (1999) therefore suggests to introduce a post-grant system similar to the one present in Europe and a number of individual European countries, such as Germany.[7] This public policy interest demonstrates that an economic analysis of the opposition mechanism is urgently needed.

The remainder of the paper is structured in five sections. We first discuss the institutional elements of the European Patent Office and its associated procedures. The institutional information provided in section 2 forms the background of our theoretical discussion in the subsequent section 3 in which we develop our hypotheses. Section 4 discusses data sources and the computation of key variables. In section 5, we first consider a number of descriptive statistics before setting up and estimating multivariate probit equations for the incidence of opposition in the sample studied here. In the subsequent discussion, we compare our theoretical expectations and the probit results. Section 6 discusses some limitations of our analysis and the implications and possible extensions of this research.

2 Patent Systems in Europe

National legal systems in Europe display considerable heterogeneity, which is a reflection of the diverse legal traditions. However, in the area of legal frameworks for patents, harmonization of legal institutions has had a long tradition. The advantages of a common European patent law were already acknowledged during the 19th century. Since then there has been a continuous effort to align the different forms of national patent legislation in Europe. Such processes of legal alignment in Europe are translated into action on a contractual basis. Thus, the national jurisdictions of the sovereign member states are not abolished and continue to exist in parallel to the new supranational contracts.

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[6] Obviously, any institution that can correct errors may also be capable of introducing new ones. Moreover, the institution itself may introduce uncertainty for the participating actors. It will be very important to study if the opposition mechanism can be employed strategically, e.g., by financially strong firms which want to deter entrants from exploiting their patent rights.

[7] Other countries which have incorporated some type of opposition mechanism in their national patent code include Australia, China, Japan, South Korea, and New Zealand. Most of these mechanisms are post-grant opposition proceedings.

It is for the same reason that Europe has reached a remarkable consensus on the patent filing and granting process, reflected in a widespread use of supranational filing and granting mechanisms. At the same time, with regard to patent litigation before courts, there remains legal heterogeneity of Europe. The opposition procedure at the European Patent Office, however, can to some extent be regarded as a centralized "first-instance challenge suit" for EPO-granted patents and can thus in part be compared to patent validity suits in U.S. civil courts. In the following we try to set out important details of European patent legislation in a very condensed form.

2.1 Historical Aspects

Three milestones in European patent legislation can be identified in retrospective: the passing of *the Paris Convention for the Protection of Industrial Property in 1883*, the rectification of the *Patent Convention of Strasbourg in 1963,* and the conclusion of the *European Patent Convention* in Munich in 1973. Before 1883, supranational arrangements in the field of intellectual property rights did not exist in Europe. Neither the premises nor the consequences of the different jurisdictions were recognized in other countries. It was due to growing international industrialization that a need for international validity of intellectual property rights was articulated at the end of the 19th century. As a consequence, in 1883 the leading European countries of the time agreed to treat foreign patent holders like domestic patent owners; and that patent priorities could from that time onward be claimed internationally. After this first step no further need for legal harmonization was felt until the end of the second World War. The efforts of the European Economic Community (EEC) towards trade liberalisation and the establishment of a common market in Europe led to the *Patent Convention of Strasbourg* in 1963. The significance of this treaty lies in the alignment of terms of material patent law, such as novelty or inventive step.[8] This alignment of material right terms in the different national legislation was a necessary step towards the conclusion of the *European Patent Convention (EPC)* in 1973. The EPC is nowadays the most important source of common European patent law. As a special agreement referring to the *Paris Convention for the Protection of Industrial Property in 1883* it regulates the filing and granting process of common European patents. It covers both, formal and material aspects of patent law. As of April 1998, nineteen European states had confirmed the treaty. By doing so they acknowledge that centrally examined and granted European patents are given the same validity as nationally granted patents. They also agree that granted European patents can be centrally attacked via opposition, i.e., in a procedure comparable to a "first-instance challenge suit". Traditional national litigation on infringement or the validity of the patent before national courts remains untouched, but loses importance.[9]

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8 For a definition of "novelty" and "inventive step" see section 2.3.

9 In addition to the mentioned supranational contracts, two other treaties have assumed major significance for Europe, i.e. the *Patent Cooperation Treaty* (PCT) and the *Agreement on Trade-Related Aspects of*

2.2 European Patents

The conclusion of the European Patent Convention in 1973 prepared the ground for the creation of a central European Patent Office which has its headquarters in Munich. Between 1978 and 1999, the European Patent Office has received 1,267,681 patent applications and has granted 479,133 patents.[10] It has therefore become one of the most important patent offices in the world. Figure 1 displays the number of EPO applications and patent grants from 1978 to 1999.

Patent protection for European member states can be obtained by filing several national applications or alternatively one EPO patent application designating the states for which patent protection is requested. Considering the fees charged by the various patent offices in Europe, a European patent application costs approximately €29,800 and thus about three times as much as a typical national application.[11] Thus, if patent protection is sought for more than three designated states, the application for a European patent becomes cheaper than independent applications in several jurisdictions. This cost advantage has made the European filing path particularly attractive for applicants that are selling goods and services in international markets. Due to the increasing application and grant numbers, the European Patent Office has now gained a level of economic importance similar to that of the United States Patent and Trademark Office (USPTO). Moreover, the opposition procedure before the European Patent Office has become an important instrument for first-instance challenges to the validity of patents granted by the EPO.

2.3 The Application and Examination Process

European patents are granted for inventions which are novel, mark an inventive step, are commercially applicable, and are not excluded from patentability for other reasons. After the filing of the application, a search report is provided by the EPO and made available to the applicant. The search report is generated by EPO staff in the The Hague office and then transferred to the examining staff in the Munich office. It describes the state of the art regarded as relevant according to EPO guidelines for the patentability of the invention. In particular, the examination report lists and classifies references to earlier patents or to documents in the nonpatent literature according to the guidelines for substantive examination issued by the World Intellectual Property Organisation (WIPO). So-called "A references" simply describe the state of the art without posing a threat to the

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Intellectual Property Rights (TRIPS). However, since these two treaties are global treaties rather than inter-European agreements, they will not be discussed in detail in this paper.

10 See the European Patent Office Annual Report 1999, Table 7.6. The application and grant figures include so-called Euro-PCT applications.

11 As in other patent systems, the official patent office fees are a relatively small part of the costs (in this case €4,300). Professional representation before the EPO amounts to €5,500 on average, while translation into the languages of eight contracting states requires €11,500. Renewal fees for a patent maintained for ten years amount to roughly €8,500. See "Cost of an average European patent as at 1.7.99", http://www.european-patent-office.org/epo/new/kosten_e.pdf (Jan. 14, 2002).

novelty claims in the application. Other classes of references (Y and X) are potentially harmful to the novelty claim and may therefore signal to the applicant (and to outsiders once the research report is published) that the patent application is weak. Category X is applicable when a referenced document is such that even when taken alone, a claimed invention could possibly not be considered novel or could not be considered to involve an inventive step. Category Y is applicable when a referenced document is such that a claimed invention could possibly not be considered to involve an inventive step when the document is *combined* with one or more other documents of the same category, such combination being obvious to a person skilled in the art. Documents are classified by the EPO staff members in The Hague who prepare the search report. The classifications therefore have pre-examinatory status, i.e., they are re-evaluated during the material examination in Munich. As we will argue later, a patent grant emerging from an application with a large number of X references may attract the attention of possible opponents.

Eighteen months after the priority date the patent application will be published. At this point, the application will normally still be under examination; thus, the patent owner will already reveal some information prior to the grant of the patent. Moreover, the content of the application is revealed even if no patent is ever issued. If engaged with the examination, the EPO will present an examination report. Once the applicant and EPO have reached a consensus on the version of the application to be granted, the patent is centrally granted for all the designated states and then translated into the respective languages. If no such agreement is reached and if the EPO declines to grant a patent, the applicant may turn to the appeals proceeding in which the reasons for the refusal to grant a patent right are reconsidered.[12] After the grant, the European patent becomes a "bundle" of national patent rights. On average, the granting process for a European patent takes about 4.2 years from the date of filing the application.

2.4 The Opposition Procedure

Once the European patent is granted, its national successors are treated like "normal" national patents that can be attacked by third parties through legal means allowed for by the respective national legislation. If the patent is invalidated in one country, this outcome does not affect its validity in the other countries in which it is valid. Up to nine months after the granting date, however, third parties can attack the European patent centrally at the European Patent Office by filing their opposition against the granting decision. As with the granting decision, the outcome of the opposition procedure is binding for all designated states. The opposition procedure is thus the only centralized opportunity to challenge the validity of European patents. After the expiration of

[12] This form of appeal has to be distinguished from appeals seeking to reverse the decisions rendered by the opposition division of the EPO.

nine months subsequent to the grant, a competitor will have to attack the succeeding national patents of the European patent in each jurisdiction, separately facing multiple litigation costs.

Opposition to a European patent is filed with the EPO. The opponent has to substantiate his opposition by presenting evidence that the prerequisites for patentability were not fulfilled, e.g., he has to show that the invention lacked novelty, and/or an inventive step, or that the disclosure was poor or insufficient. The opposition is formally admitted by the EPO where an opposition division decides on the case. At the end of the opposition procedure the chamber may uphold the patent without amendments, or it may amend[13] or even revoke[14] the patent. Patents are revoked in about one-third of all cases.[15] The decision affects all of the "designated states," i.e., the states for which the patent applicant sought to obtain a patent.

A further interesting aspect of the opposition procedure that distinguishes it from an "ordinary" litigation before civil courts concerns the possibility of settlement between the litigating parties. Once an opposition is filed, the EPO may continue to decide on the case even if the opponent no longer actively pursues opposition. Thus, opponent and patent holder may not be free to settle their case outside of the EPO opposition process once the opposition is filed.[16]

Both the patent holder(s) and the opponent(s) may file an appeal against the outcome of opposition procedures. The appeal has to be filed within two months after the receipt of the decision of the opposition division, and it has to be substantiated within an additional two months. The Board of Appeal is the final instance at the EPO to decide on the validity of the contested European patent. The official fee for filing an opposition is €613; for filing an appeal against the outcome of opposition, the fee is €1022. But the total costs to an opponent or the patent holder are much higher. Estimates by patent attorneys range between €15,000 and €25,000 for an opposition case (for each party). Approximately the same amount would be due for an appeal against the outcome of the opposition proceedings.

Figure 2 displays the rate of opposition for the time period from 1980 to 1998.[17] We plot here the number of opposed patent grants divided by the total number of patents granted in a particular

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[13] An amendment normally results in a reduction of the "breadth" of the patent by altering the claims which define the area for which exclusive rights are sought. See Straus (1996) for a detailed discussion of the legal status of the patent rights during this process.

[14] On average, the opposition procedure takes around 2.2 years if the patent is revoked and about 4 years if the patent is amended.

[15] See EPO (1999), p. 17 and Merges (1999), pp. 612-614. For the sample used here, we present estimates of the revocation and amendment rates in section 4.1 of the paper.

[16] EPO may, but will not necessarily pursue the opposition procedure after the opponent's withdrawal from his attack.

[17] Since opposition must be filed within nine months after a patent is granted, the application cohorts from 1978 to 1996 were attacked by opposition cases dated between roughly 1980 and 1998. The lag corresponds to the examination period between application and grant.

year. Leaving aside the early period after the EPO commenced operations, the rate of opposition has intially been on the order of 8 percent. It has declined to about 6.5 percent over time, but it is still extremely high in comparison to the likelihood of patent litigation in the U.S.[18] The discrepancies between the U.S. and EPO figures may mainly be driven by cost differences.

2.5 National Litigation

In cases of unsuccessful opposition and appeal against commercially valuable patents, third parties may try to attack the national successors of the European patent in the designated states. As of today, this option is not touched by the harmonisation of the European patent laws. Thus, from a purely *procedural* standpoint, unsuccessful opponents at the EPO can theoretically initiate *independent* and *unprejudiced* subsequent national challenge suits in all designated states and try to exploit their "second chances" of attacking the patent holder. However, national authorities can refer to the *material* arguments brought forth during former trials; thus, the probability of winning a national trial after having lost at the European level may well be reduced if the arguments brought forth during the opposition procedure are also admitted during the subsequent suit at the national level. This, in turn, re-emphasizes the importance of the EPC opposition as the central "European validity suit". Another argument re-stating the importance of the EPC opposition procedure arises from the difference in national patent jurisdictions. For the opponent it is difficult to achieve economies of scale, thus making it very expensive to attack the national successor patents in all of the designated states. The costs for litigation in any one of the national courts have been estimated to be between €50,000 and €500,000, depending on the complexity of the case.[19] This cost structure makes an attack at the European level via the opposition procedure particularly attractive for a potential competitor of the patent holder.

A study of the relationship between validity suits in civil courts and opposition would be of some interest, since the outcomes of opposition may impact the incidence and outcomes of civil court proceedings. However, given the heterogeneous legal frameworks and the lack of appropriate data in Europe, such a study is beyond the scope of this paper. Moreover, in the case of patents that are revoked in the opposition procedure, there can be no subsequent validity challenge in civil courts. Since opposition is the first and – in terms of frequency – dominating procedure[20], we focus on

[18] Note that the term "patent litigation" is often used to refer to either validity challenges or patent infringement suits. Lanjouw and Schankerman (2001) estimate the incidence of validity challenges to be at 1.05 percent of all patent grants in the drugs and health field (which in their case includes cosmetics). See Lanjouw and Schankerman (2001, Table 1). They point out that many of the US challenge suits against patents arise as a consequence of infringement suits, since the defendant usually seeks to assert that that the infringed patent had no validity in the first place.

[19] See the contributions in Ropski (1995) for some rough estimates of costs and a qualitative comparison of patent litigation procedures in various countries.

[20] For the case of validity challenges in Germany we have access to some data. Contrary to other countries in which validity suits are decided in civil courts, the German legal system separates questions of validity

determinants that lead to validity challenges using this mechanism.

3 Theoretical Aspects - The Selection of Opposition Cases

3.1 A Simple Theoretical Model

In order to derive our hypotheses in a systematic manner, we briefly introduce a simple formal model of opposition which is based on the classical study by Priest and Klein (1984).[21] To simplify matters, we consider a world in which parties make imprecise assessments of case quality and decision standards, but where information is distributed symmetrically.[22] The opponent and the patent-holder may have diverging subjective assessments of the outcome of the case, but the value of the patent (i.e., the profits in the duopoly or monopoly case) are given. To qualify for opposition, any case must satisfy the condition that the expected value for the opponent will dominate the expected cost of opposition. In other words, we rule out that the opponent "bluffs" and threatens to oppose in circumstances under which the true expected benefit from opposition is lower than the cost.[23] If the 'suit' is feasible, then the parties may still be settled prior to the expiration of the opposition period, i.e. within nine months after the patent has been granted. We develop these two conditions in the context of a simple model and then discuss some of the comparative statics in a stylized manner.

In the case of opposition proceedings, it is important to recall one distinct institutional feature. Once filed, the European Patent Office can pursue an opposition case even if the parties involved have achieved some kind of understanding. Suppose that the case has been filed, but the opponent has withdrawn after obtaining a license from the patent holder. Such a settlement would be attractive, since both firms will now enjoy patent protection (even if the patent has been assigned

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and of infringement. While the latter are decided by specialized civil courts, the former are delegated to the German Patent Court. Harhoff, Scherer and Vopel (2003, Table 3) document that out of the 57,782 patent applications with priority year 1977 at the German Patent Office, 24,116 patents were initially granted. Of these, 2,036 were opposed, but only 73 patents were subsequently subject to an annulment suit. We have also obtained data from the German Patent Court which show that between 1978 and end of 2000, only 421 patents granted by the European Patent Office were attacked in the German validity (annulment) proceedings. This figure compares to 25,988 opposition cases against patents in which Germany was named as a designated country. The comparison of these figures demonstrates (for the case of Germany) the overwhelming importance of the opposition procedure as compared to the national validity challenge. We would like to thank Thomas Baumgärtner, Judge at the German Patent Court, for making these data available.

21 Lanjouw and Lerner (1998) use the Priest and Klein model to interpret conditions under which infringement cases will be brought to trial.

22 In Waldfogel's terminology, this is the case of divergent expectations (DE) which he carefully distinguishes from the case of asymmetric information (AI). Since we cannot distinguish among the different theories in our data, we do not present the arguments in detail. See Waldfogel (2000) for an empirical test the results of which favor the DE hypothesis.

23 Frivolous suits are possible under asymmetric information (Bebchuck 1984) which we consider below.

erroneously or if it grants too much scope to the owner and licensees). The European Patent Office may nonetheless pursue the case and subsequently revoke the patent. We would therefore assume that settlement negotiations tend to take place mostly prior to the filing of the opposition (if at all). Thus the following considerations are based on the assumption that once an opposition is filed, it is also tried. Settlement may take place, but it would occur prior to filing the case.[24] Thus unlike the case of ordinary litigation, where we observe the filing of suits even if they are settled before trial, we do not observe opposition cases that "settle."

We distinguish two cases. Our first case is one in which successful opposition to a patent grant transforms a monopoly to a duopoly. Suppose that a patent has been granted to one firm and the patent would allow the firm to earn monopoly profits Π^M. Another firm considers the benefits and costs from filing an opposition and letting it go to trial versus settlement of the dispute. We assume in a somewhat simplifying manner that the trial can only have two outcomes – the rejection of the opposition or the revocation of the patent right. Should the opponent prevail in having the patent revoked, both firms will be able to earn duopoly profits Π^D in the market.[25] If the opposition is rejected, the attacker will receive zero profits. Note first that the case will only qualify for opposition if

$$p_O \Pi^D - c_O > 0 \tag{1}$$

where p_O is the likelihood of successful opposition as perceived by the opponent, and the opponent's total cost of opposition proceedings is given by c_O, which for the moment, we treat as exogenously given. Cases that qualify for opposition may either be settled or tried. For our discussion of a pre-trial settlement solution, the threat point of the opponent is given by

$$p_O \Pi^D - c_O \ . \tag{2}$$

The threat point for the patent holder is given by its expected value from trial

24 Our interviews with patent attorneys suggest that this is indeed the case - estimates of the settlement frequency range suggest that between 10 and 25 percent of disputes are not filed, but settled between the parties.

25 If entry is free once the patent is revoked, more firms may enter so that profits are driven to zero. Note that in this case a potential opponent may not wish to oppose the patent, since the opposing firm creates a public good for every other firm in the industry, but bears the full cost of trial. In this case the threat point would be negative. In the case considered later, the opponent attacks a patent holder entering the market. If the *ex ante* market structure is an oligopoly, there will typically be incentives for firms to free-ride on the attacks of other potential opponents. Our model does not explicitly consider the coordination problem that may exist between potential opponents. There are various means by which coordination could be supported. First, oligopolies are typically asymmetric so that one of the players may have sufficiently strong incentives to go ahead with an opposition. Moreover, in repeated interaction potential opponents may find means to oppose patents in an alternating sequence. In such a scenario, each firm will cover the total costs for one (or a few) oppositions, but it will also benefit from all the further successful oppositions filed by others. Qualitative evidence from exploratory interviews with patent attorneys suggests that coordination does indeed take place.

$$\left(1-p_P\right)\,\Pi^M + p_P\,\Pi^D - c_P\,, \tag{3}$$

where p_P is the likelihood of successful opposition as subjectively perceived by the patent holder. The cost of opposition proceedings (including attorneys' and patent office fees) is given by c_P. The differences in the subjective probabilities simply reflect diverging expectations – both parties may assess the quality of their case and the decision standard with some error, but neither party has any privileged information. The trial value of the game is given by the sum of the threat points. The cooperative value of the game is the industry profit in case of settlement net of total settlement costs S, i.e., $\Pi^S - S$. We treat the profit level in the case of cooperation separately here, since it may exceed the industry profits of a duopoly if some collusive elements are present in the licensing or side-payment setup chosen by the firms. Hence, we assume that $\Pi^M \geq \Pi^S \geq 2\Pi^D$. Settlement will not occur (i.e., opposition will occur) if the trial value exceeds the cooperative value of the game. This comparison yields the inequality

$$\left(1-p_P\right)\left(\Pi^M - 2\Pi^D\right) + \left(p_O - p_P\right)\,\Pi^D + \left(S - c_P - c_O\right) \geq \left(\Pi^S - 2\Pi^D\right). \tag{4}$$

The first term captures how attractive the monopoly position is as compared to the duopoly case from the patent-holder's perspective. The higher the wedge between monopoly and industry duopoly profits, the less likely the patent holder is to settle, in particular if he perceives the likelihood of successful opposition to be low. Ceteris paribus, we would expect this difference to grow with the level of monopoly or duopoly profits. The second term captures the effects of diverging expectations of case quality and decision standards. If the opponent is optimistic (i.e., if his subjective probability of winning is higher than the patent holder's assessment), then litigation will again become more likely, especially if the level of duopoly profits is high. The third term captures the cost disadvantage (or advantage) of the settlement solution – high trial costs will make settlement more likely, high settlement costs will drive the parties to a trial solution, *ceteris paribus*. One would usually assume that settlement is less costly than a trial. In the case of opposition against patent grants, this conclusion is not necessarily warranted. First, the costs of conducting the trial are born by the European Patent Office. The two parties involved have to take into account a fee for filing opposition and attorney costs. Since the filing fee is minor[26] and since settlement negotiations would also be conducted by attorneys, settlement may actually be more expensive to the parties than the trial. Finally, the term on the right-hand side of the inequality captures the effect of a cooperative solution. The higher the settlement profit is in comparison to the duopoly solution, the more likely settlement will be. This term will be zero if cartel authorities do not allow firms to enter arrangements that leave them more than the duopoly profits.

Now we consider another case in which successful opposition actually functions to *maintain* a monopoly. Suppose that a firm has received a patent that allows it to enter an industry dominated

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26 See section 2.4 for details.

by an incumbent. The entrant's patent may, for example, protect a technology that neutralizes the former technological lead of the incumbent. In this case the incumbent may oppose the patent right, since it threatens the existing monopoly. The threat point of the ex ante monopolist (the opponent) is given by

$$(1-p_O)\,\Pi^D + p_O\,\Pi^M - c_O \tag{5}$$

while the entrant views

$$(1-p_P)\,\Pi^D - c_P \tag{6}$$

as her threat point. The condition for an opposition case to be filed and tried is then given by

$$p_O\left(\Pi^M - 2\Pi^D\right) + \left(p_O - p_P\right)\Pi^D + \left(S - c_P - c_O\right) \geq \left(\Pi^S - 2\Pi^D\right). \tag{7}$$

As a comparison of (4) and (7) show, ex ante asymmetries in the market positions may affect incentives to file an opposition case. Hence, a structural approach to estimation would also necessitate a careful operationalization of the market conditions. For our reduced form estimation, however, the conclusions for the two cases are similar. As the stakes increase and as the cost advantage of settlement decreases, opposition is more likely to occur. And the higher the opponent's anticipated probability of winning the case and the lower the patent holder's anticipated probability of losing the case, the more likely opposition will be.

We demonstrate the first point graphically for the first case in which the opponent can gain a duopoly position if the opposition case is successful. In Figure 3, we consider a profit-probability space und characterize parameter regions in which opposition would occur. To simplify matters, let us assume for now that diverging expectations are not present. Hence, in equation (4) the second term would vanish. We also assume for the moment that the settlement solution duplicates the duopoly solution, i.e., antitrust authorities can prevent firms from engaging in collusive licensing agreements. Hence, the right-hand side term in equation (4) is zero. Furthermore, let the monopoly profit Π^M be equivalent to $(2+\alpha)\Pi^D$ where $\alpha>0$ measures the attractiveness of the monopoly position as compared to the industry profit in a duopoly. Equation (4) implies that for opposition to occur we need

$$(1-p)\alpha\,\Pi^D \geq -\left(S - c_P - c_O\right) \tag{8}$$

Moreover, recall that for opposition to be feasible in a world without bluffs, we have to have

$$p\,\Pi^D - c_O > 0. \tag{9}$$

In Figure 3, we plot parameter combinations of p and Π^D that satisfy these conditions. As can be seen from this figure, higher settlement costs $\overline{S} > \underline{S}$ make opposition more likely, since the locus of equation (8) shifts downwards. Similarly, higher costs of opposition (to the opponent) $\overline{c}_O > \underline{c}_O$ make opposition less likely to occur, and an increase in the level of profitability (as measured by the level of duopoly profit Π^D) will tend to enlarge the range of *p*-values for which opposition occurs. Moreover, equation (8) demonstrates that larger values of α will also shift the locus of the settlement curve downwards – the likelihood of opposition (non-settlement) increases as the monopoly position becomes more attractive.

These simple considerations neglect the possibility of asymmetric information. In the model developed by Bebchuk (1984), the defendant knows the probability of winning while the plaintiff only knows the distribution of that probability. The less well-informed plaintiff makes a take-it or leave-it settlement offer which in some cases turn out to be unacceptable to the better-informed defendant. These offers will therefore be rejected and a trial ensues. Thus, the likelihood of trial versus settlement should increase as the extent of informational asymmetries grows. Similar conclusions emerge from other models with asymmetric information between plaintiff and defendant.[27] We do not specify these models in detail, but simply take from them the prediction that as information is distributed more asymmetrically, the likelihood of an opposition case increases.

3.2 Hypotheses and Choice of Industry

While there is no single model that captures all possible situations in which opposition cases may occur, some conclusions can be drawn from the above and the literature. In particular, we would predict that the likelihood of observing opposition increases as

1. expectations increasingly diverge;
2. information is distributed more asymmetrically;
3. the stakes increase, i.e., as the level of profits rises;
4. the costs of trial (opposition proceedings) decrease in comparison to the costs of settlement.

We do not offer a structural test of these predictions here, since that would require considerably more detailed data than were available for this paper. However, a reduced-form test of some of the predictions is feasible. To perform such a test, we first need to select a group of patents that is suitable and then identify variables that can serve as observables approximations for the variables implicit in the theoretical models.

[27] See, for example, Png (1983). Waldfogel (1998) provides an empirical test of the diverging predictions of AI (asymmetric information) and DE (diverging expectations) models.

As to our choice of industry, we need to select an area in which patents perform the function that is implicit in our theoretical model– i.e., where patent protection potentially endows the patent holder with a monopoly position and where there are no alternatives to patenting, e.g. in the form of trade secrets.[28] Both in pharmaceuticals and biotechnology, patenting is usually the conclusion of a time- and resource-consuming R&D process, hence, much attention is paid to finding the most effective means of earning a return on these expenditures. The field of pharmaceuticals is the one with the strongest effect of patent protection and relatively low relevance of trade secrets (Levin et al. 1987, Cohen et al. 2000). As these studies show, in a large number of other sectors, patents can be "invented around" and do not convey strong protection. Our choice also reduces the likelihood that patenting is merely a strategic process in which firms seek to generate patents as bargaining chips for cross-licensing negotiations or as a strategic threat against competitors, as it appears to be the case in the semiconductor industry (Hall and Ham 2001). To test our hypotheses, we would also like to identify in our data various sub-groups of patents that are subject to different levels of technological and market uncertainty. This is the rationale for including biotechnological patents in our analysis. Again, patenting is important in this sector, and alternative means of generating returns to R&D (such as secrecy) are typically not available. Predictions (1) and (2) suggest that rates of opposition will be particularly high for technical fields in which asymmetric information and diverging expectations are pronounced. Increasing uncertainty would therefore be associated with higher rates of opposition against patent grants. This is likely to be the case for relatively new technical areas, such as special areas of biotechnology in which applicants seek patent protection for new microorganisms, enzymes and recombinant DNA processes. Below, we use four-digit IPC classifications to test this hypothesis. The reference group for our tests are patents whose main IPC classification is C12M. We expect that there is comparatively little uncertainty in this field, since it involves the patenting of machinery and process equipment. The working principles of the equipment are well-known. Other IPC fields taken into account are C12N (microorganisms or enzymes), C12P (fermentation or enzyme-using processes), and classical pharmaceuticals (A61K, without cosmetics) for which we expect higher opposition rates than for the reference group, *ceteris paribus*.

Other features of the EPO research and examination system allow us to capture situations of asymmetrically distributed information. Recall that the process of communication between patent applicant and patent examiner is a kind of negotiation. By and large, we would expect the patent-holder to be well-informed about this process while the potential opponent has no direct knowledge of the information exchanged. This is particularly relevant when novelty and inventive step of the patented invention are assessed in comparison to the state of the art. As described in section 2.3 of the paper, the patent examiner receives a research report from EPO office staff at the The Hague

[28] While the institutional characteristics of the pharmaceutical and biotechnology industries provide a good fit with the theoretical model, we also need to point out that our results may not be generalizable to other technical fields.

office in which the research branch of the EPO has collected prior art and has labelled these references – X-labeled references indicate prior art that is a potential threat to the novelty claims of the patent. The research report is published at some point by the EPO – we therefore assume that similar information will be available to the potential opponent, but that the result of the communication process will only be known to the patent applicant and the examiner. Thus, to the extent that the discussion resolves disputes between examiner and patent applicant, the opponent will find herself disadvantaged with respect to the information she has about the examination and granting process. While this is generally the case, we consider patents with a large number of X-labelled references to be particularly exposed to informational asymmetries.[29] Uncertainty (and possibly asymmetric information) may also arise as a function of the patent's complexity which is mirrored by the number of claims included in the patent. We include the number of claims following Lanjouw and Schankerman (2001) who argue that as the number of claims increases, a legal attack singeling out some of these claims is getting more likely.

Prediction (3) states that the likelihood of opposition will increase with the value of the patents in dispute. We do not have estimates of the monetary value of the patents considered here. But from earlier studies we know that there is a strong relationship between patent value and the number of citations that a patent *receives* from subsequent patents.[30] Furthermore, an additional indicator of patent value is the size of the patent family, i.e., the number of jurisdictions in which patent protection has been granted for the invention. We use the number of designated states for which the applicant obtains patent protection once the European patent becomes a bundle of national patent rights as an additional proxy for patent value. In addition, we include a dummy variable for patent applications that were designated as PCT (Patent Cooperation Treaty) applications, i.e. cases in which the patent applicant reveals his preference for broad international patent protection, going typically even beyond the designated EPC countries.

Citation measures provide additional variables that are indicative of the patent's value. The number of references to prior patents[31] and to the nonpatent literature[32] have also been found to be positively related to patent value. These measures have also been constructed for the present dataset, but their sign is not unambiguous. For example, references to prior art described in the scientific literature may be correlated positively with patent value, but may also strenghten the

[29] An alternative interpretation of this variable is that it does indeed indicate patents for which opposition will be more successful. Note that in equation (4) the likelihood of observing opposition is increasing the success probability, while the reverse holds for equations (7). We cannot measure the correlation between the incidence of X-labeled references and outcomes, but intend to do so in the future.

[30] See, e.g., Trajtenberg (1990), Harhoff, Narin, Scherer, and Vopel (1998), and Harhoff, Scherer, and Vopel (2003).

[31] See Reitzig (2002) for a survey. The relationship between "backward citations" (both to the patent and the non-patent literature) and patent value is documented for German patents by Harhoff, Scherer and Vopel (2003).

[32] See Meyer (1999) for a survey.

patent against legal attacks such as opposition. In our empirical estimates both effects may be present, and on theoretical grounds alone it is not clear which effect will dominate.

Prediction (4) cannot be tested using our data, since we do not observe the costs of opposition or settlement. Nor do we have proxy variables at hand which we can utilize to this purpose. But we hypothesize that patent holders with relatively large portfolios will be able to offer settlement offers to attackers more easily than other patent holders, e.g., via cross-licensing contracts. The value of such agreements should be particularly high in technical fields that are not "densely populated" by patents. One can argue alternatively that in industries with substantial licensing, an attack on a patent holder with a large portfolio may trigger a non-cooperative response. Large patent portfolios may therefore allow the patent holder to retaliate in some fashion against the attacker. We would therefore expect a negative effect of patent portfolio size on the incidence of opposition. Again, if there are a large number of patents in a technical field in any case, then bilateral implicit collusion may not be valuable. The effect of a large portfolio is therefore likely to diminish as the total number of patents in a field increases.

Finally, we include a large number of control variables in our probability model. These do not have a clear interpretation, but are likely to control for additional sources of variation. First, we introduce dummy variables for the most important owner nations. Differences associated with the nationality of the owner may be correlated with variations in the average quality of patent applications filed with the EPO. To give a simple example: a Japanese firm which has already received several patents for its domestic market will not necessarily patent all of its domestically protected inventions in Europe, since the additional costs will induce a selection of particularly valuable patents.[33] Hence, we expect that the quality (and value) of patents owned by European patent owners will on average be lower than the quality of Japanese and US patents filed in Europe.

4 Data Issues

4.1 Data Sources

We use three different data sources for our study. The ELPAC data base contains information on European patents and patent applications filed between 1978 and 1996. The data include the names of the inventors, applicants and opponents, designated states, process dates, international patent classifications and decisions of granting and opposition procedures. Our version of ELPAC contains 813,979 observations. We also use information from the ESPACE databank to add observations where ELPAC is not complete. The ESPACE databank basically contains the same

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[33] See Putnam (1996) for an analysis of foreign filings.

information as ELPAC; however, ESPACE covers the filing and granting process more completely than ELPAC whereas ELPAC is more complete with respect to the opposition procedure. For the compilation of the citations we drew basic information from the REFI database and complemented the information with citation data downloaded from the EPO's patent register (available at http://www.epoline.org) for PCT patent applications.[34] From these databases, we selected pharmaceuticals and biotechnology patents via their main IPC classifications.[35] We identified 13,389 European patents in the biotechnology and pharmaceutical fields between 1979 and 1996. Of these, 1,158 patent grants (8.6 percent) were opposed.

4.2 Variables

In the following sections, we briefly describe the variables computed from our three data sources.

Opposition. We create a binary variable to distinguish between patents that were opposed from those that were not opposed. This variable reflects the endogenous outcome we want to model.

Number of designated states. Putnam (1991) and other authors have argued that information on family size (the number of jurisdictions in which patent protection is sought) may be particularly well suited as an indicator of the value of patent rights. Studies by Putnam (1996) and Lanjouw et al. (1998) have shown that the size of a patent family and the survival span of patents are highly correlated. While we do not observe the global size of the patent family in our data, we can construct variables for the designation of the patent in the different member states of the European Patent Convention. In essence, this reflects the European family size. Given the fee schedule of the EPO, it is clear that firms seeking to designate the patent right for a large number of EPC member countries face a considerable increase in total patenting expenses. However, there are some economies of scale in that some types of fees (e.g., for translation) are fixed. In our multivariate analysis, we therefore use the logarithmic transformation of the number of designated states to reflect the declining marginal cost of patenting in another EPC country. We expect the likelihood of an opposition to rise with the number of designated states.

Number of international patent classification (IPC) assignments. During the EPO research and examination process, patents are assigned up to 9-digit categories of the IPC system. Patented

[34] In the earlier dicussion paper version (Harhoff and Reitzig 2002), we used citation and reference counts derived from European search reports as summarized in REFI. Citations made by the EPO in its function as the World Intellectual Property's (WIPO) international search authority (ISA) were not included in those counts. The use of the information from epoline.org corrects the earlier weakness of our database. There are no major changes in our results, but the coefficient estimates we obtain using the complete citation data are generally more precise.

[35] We have included patents with primary IPC classification C07G, C12M, C12N, C12P, C12Q, C12R, C12S. The latter two IPC classes contained only 4 patents and were subsumed under C12Q. The pharmaceuticals patents come from IPC A61K, but we exclude the subclass A61K7 (cosmetics).

inventions may belong to diverse technological fields, i.e. they may be assigned different IPC codes. The broader the relevance of the patent, the more potential opponents it may therefore have. The number of different IPC classifications may therefore be positively correlated with the likelihood of opposition. This argument was put forth by Lerner (1994) who suggests that broader patents are more valuable ones, and that patent scope can be operationlized via the number of (non-identical) IPC classifications. An opposing argument would suggest that the likelihood of opposition should decrease with an increasing number of different IPC codes, since the invention is more general and therefore has less immediate relevance for market outcomes.

Grant lag. While some of the above variables capture aspects of the complexity of a patent, we also include the lag between application and grant decision as an additional overall measure of complexity. As we noted before, the interaction between patent applicants and patent examiners is a kind of negotiation process. The duration of this process will, among other things, be driven by the inherent complexity of the subject matter. On average, the grant period takes 4.88 years for patents in our sample, but displays considerable dispersion. With increasing complexity (and thus longer grant lags), we would again expect that asymmetric information and diverging expectations may play an ever more important role. We therefore expect to see a positive partial correlation between the likelihood of opposition and the grant lag.

PCT application. Patent applicants who designate their EPO application as a PCT application signal that they are interested in patent protection extending beyond the EPC member states. Thus, this type of application signals the intention to commercialize the protected invention in a large number of national markets. However, a PCT application also allows applicants to postpone decisions regarding the scope of international protection for up to 30 months.[36]

Number of claims. We view the number of claims as a potential determinant of oppositions, since the complexity of patents and the likelihood of legal disputes is going to increase as the number of claims goes up. Lanjouw and Schankerman (2001) interpret the number of claims as a value correlate. While this view may be correct, it is hard to disentangle it from the argument that more complex (but not necessarily more valuable) patent rights simply create divergent expectations and/or asymmetric information and thus invite stronger opposition. Therefore, the inclusion of this variable can be interpreted as testing either hypothesis 3 or hypothesis 2 as listed above.[37] To account for the skew distribution of claims, we introduce this variable in logarithms into the probit equation.

Citations received from subsequent patents (forward citations). If a patent receives citations from other future patents, this is an indication that it has contributed to the state of the art. Earlier

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36 See Reitzig (2002, 2003) for a more detailed explanation of this indicator
37 Again, we use a logarithmic transformation here, since the number of claims ranges between 1 and 274.

studies have shown that forward citations are positively correlated with the monetary value of the patent (Harhoff, Scherer and Vopel 1999; Lanjouw and Schankerman 1999; Trajtenberg 1990). In our paper, forward citations are computed within the EPO system only, i.e. we only identify how many future citations a patent received from subsequent *European* patents. We count the number of references to the patent under consideration in patents filed within four years of the filing date of the original patent. We expect the likelihood of opposition to increase with the number of citations received by subsequent patents. Since the distribution of citations is quite skew, we use a logarithmic transformation, as with the claims variable.

References to patents (backward citations). The search report of the EPO yields information on the state of the art relevant for the patentability of the application. State of the art is mostly described by patent or nonpatent literature. Relevant references are cited by the examiners during the examination of the patent application. Furthermore, the cited references are pre-classified by the EPO office in The Hague which composes the search report prior to examination (see section 2.2). These classifications are employed in this study as indicators of the extent of asymmetric information between patent holder and examiner. In particular, a large number of X-type references should go along with significant informational advantages on the side of the patent holder.

For our analysis we construct several backward citation variables. First, we count the overall number of backward citations listed in the search report. We expect this variable to be positively correlated with the likelihood of an opposition, since it captures the extent of patenting activity in a certain technical field and hence the potential profitability of inventions falling into that domain. In our initial specifications we transform the simple count variable by taking the logarithm of one plus the count variable.[38] The informational content of this backward citation variable may be driven in part (or completely) by the type of reference, rather than the total number of references. The classification of patent references into the A, X, Y groups and a residual category without detailed assignment allows us to include the counts of each of these types of references. Again, we use a logarithmic transformation of the linear count variables. We expect that as the number of referenced X and Y documents increases, a patent will face a higher likelihood of opposition because of the impact of these classifications on asymmetric information and diverging expectations.

References to the nonpatent literature. Patents may be based in part or fully on new scientific knowledge.[39] Since published research results can be used to document the state of the art against which the application has to be evaluated, patent examiners will then search for relevant references in the scientific literature. As in the case of references to the patent literature, a relatively high

[38] We test this functional form assumption below against a linear (non-logarithmic) version.

[39] The growing importance of the linkage between private patenting activities and scientific knowledge has been documented by Narin, Hamilton, and Olivastro (1997).

number of references to the scientific literature may therefore indicate patents of relatively high value. For patents in the chemicals and pharmaceuticals industries, this hypothesis was confirmed by Harhoff, Scherer and Vopel (1993), using actual estimates of the monetary value of German patent rights which were regressed on patent value indicators. Following our main hypothesis, patents with a large number of references to the nonpatent literature should therefore face a higher likelihood of opposition.[40]

Size of applicant's patent portfolio. We construct a further variable that counts the cumulative number of previous EPO patent grants the applicant has already received. As the patent portfolio of the patent holder increases, the rate of opposition is likely to decrease for a number of reasons. First, as Lanjouw and Schankermann (2001) point out, a larger portfolio opens new settlement options via licensing. Moreover, firms with considerable patenting activity are likely to be engaged in repeated interactions which may support settlement solutions. Second, a larger patent portfolio should reduce the impact of a successfully opposed patent, both on the applicant's and the opponent's profits. Thus, the stakes are reduced and opposition should be less likely.

Crowdedness - cumulative EPO patent grants within technical field. The more attractive a technical field, the higher should be the cumulative number of patents. This form of "crowding" is likely to raise the likelihood of opposition. Our measure for "crowdedness" is the cumulative number of patents within a four-digit IPC classification. This variable captures time-variant information as does the previous one.

Interaction between crowdedness and portfolio size. The value of having a large portfolio of patents may be particularly great in crowded technical fields. We therefore introduce the interaction term as an additional exogenous variable.

Ownership. An invention can only be made by individuals. The applicant (and later on patent-holder) may be either an individual, a firm or a group of individuals and firms. We construct a variable for the type of ownership (corporate or individual) for each patent by comparing the inventor's and the applicant's name. The patent is assigned individual ownership if the inventor's name and the applicant's name are the same. We also create binary variables for owners from the U.S., Germany, Japan, France, Great Britain, Switzerland and a residual group of all remaining countries.

[40] Measures of this type have been discussed and analyzed by Schmoch (1993) and Meyer (1999).

5 Empirical Specification and Estimation Results

5.1 Descriptive Statistics

Our empirical analysis is based on data covering all European patents in the biotechnology and pharmaceuticals industry with application years from 1978 to 1996. The data include information on the filing date, the date of opposition, the number of designated states, the IPC codes assigned, the nationality of the patent owner and the type of ownership; furthermore they comprise forward and backward citations and references to the nonpatent literature for each European patent. The complete data set contains 13,389 European patents and 1,158 opposition cases (8.64 %). We can describe the outcomes of these cases only broadly, since we do not have final outcome data (after possible appeals) for 231 cases (20.0 percent of the 1,158 opposition cases). The patent was revoked in 30.5 percent and amended in 40.6 percent of the remaining cases. The opposition was rejected in 18.3 percent of the cases for which we have information on final outcomes. In 10.5 percent of the cases, the opposition procedure was closed, either because the opponent withdrew the case and the EPO did not pursue it on its own behalf, or because the patent holder decided to let the patent lapse. These statistics support our view that opposition is an important post-grant correction mechanism that deserves further study.[41]

Summary statistics for these patents in our sample are given in Table 1. We only comment on a subset of the variables. On average, the applicant designates 10.4 EPC member states when filing his application. The patents have (on average) close to 2 IPC classifications. The mean grant lag is 4.88 years. A large share of the patents (25.3%) has been applied for via the PCT application path. Forward citations range from 0 to 47 citations per patent at an average of about 1.3 citation per patent; backward citations range from 0 to 57 citations at an average of about 3.1 citations per patent. The share of X documents among all referenced patents is 29.2%, the share of Y documents is 19.3%, and about 24.3% of the cited documents are of type A. For slightly more than one quarter of the patent references (27.3%), we do not have a classification of the reference type. The average portfolio size is 30 patents. The share of "inventor applicants" (independent inventors) is 6.5 percent. The lion's share of the granted patents comes from the US (33.8%), Japan (19.1%) and Germany (14.1% - reference group).

Tables 2 to 5 display the relationships between the incidence of opposition and four of the exogenous variables, i.e., forward citations, backward citations, references to the nonpatent literature, and the number of designated EPC states. In these tables we present data on the

[41] The distribution of outcomes has been quite stable from 1986 to 1995. Prior to 1986, there are not enough cases for a study of time trends. When we pool opposition cases from grant years 1986/87, 1988/89, 1990/91, 1992/93 and 1993/94, we cannot reject the hypothesis that the distribution of outcomes has not changed over these two-years intervals at the 10 percent level (χ^2=23.3, df=15, p=0.108

distribution of the exogenous variables as well as data on the bivariate relationship between these variables and the incidence of opposition. We present these statistics for the total number of patents in the sample, and separately for three national groups of patent owners, the U.S., Japan and the remaining, mostly European countries.

As is evident from Table 2, forward citations are highly correlated with the likelihood of opposition in the overall sample and in each of the national groups. The rate of opposition increases monotonically with the number of forward citations. The group of patents receiving more than 9 forward citations is in fact attacked in 44.5 percent of all cases, nearly twice as often as the group of patents which is referenced 7 to 9 times. It is also clear from Table 2 that Japanese patents are attacked far less frequently than those of U.S. and other owners, but it is not clear whether this is driven by differences in patent quality (in the sense that Japanese patents are legally "stronger"), or by differences in patent value (in the sense that Japanese patents tend to be more incremental than patents from other owner nations).

Table 3 reveals that there is also a significant relationship between backward citations and the incidence of opposition, although the relationship appears to be much weaker than in the case of forward references. This result also holds for the sub-samples of Japanese owned patents and those mainly held by European owners. However, backward citations are not significantly correlated with the likelihood of opposition when restricting the sample to U.S. owners.

Table 4 summarizes the relationship between opposition and the number of references to the non-patent literature. Again, in the overall sample we find a significant relationship ($p<0.001$), but this correlation is mainly driven by the U.S. sub-sample. References to the nonpatent literature are not significantly associated with the likelihood of opposition for Japanese owned patents and for patents owned by mostly European patent holders. These differences may reflect diverging compositions of the national patent portfolios, e.g. by technical field or other variables that are also related to opposition.

Finally, the results summarized in Table 5 confirm that the likelihood of opposition is correlated positively with the number of designated EPC states in our bivariate analysis. However, the relationship does not appear to be a monotonic one. Obviously, the decision to seek patent protection in a particular country may also be driven by variables that we have considered before, e.g., the patent's anticipated legal strength. It will therefore be important to study the effects of all variables described before in a multivariate analysis.

In Table 6, we provide an overall view of the bivariate relationships between the metric variables used in the following multivariate analysis. Most of the (absolute) bivariate correlation coefficients are below 0.2. However, a few relationships are stronger ($|\rho|>0.2$) and deserve attention. The logarithm of the number of claims and the number of non-identical IPC classifications have a

Pearson product-moment correlation of 0.217. There is also a positive relationship between the grant lag and the claims variable (ρ=0.224), presumably because complex patents (with a large number of claims) take longer to examine. The correlation between the claims and the citations measures is positive (ρ=0.254); moreover, the higher the number of (forward) citations, the longer are the respective grant lags (ρ=0.202). Grant lags and the number of nonpatent references are also positively correlated (ρ=0.221) while there is no such relationship between grant lags and patent references. Patent examiners may find it easier to assess the relevance of prior art contained in patent references than in nonpatent sources. Technical areas in which firms typically designate a large number of EPC states for patent protection tend to be "crowded" (ρ=0.321), i.e. there is a large number of patent applications seeking to establish intellectual property rights in these fields.

5.2 Multivariate Specifications and Results

We now discuss the results from our multivariate probit specifications, which are summarized in Table 7. In order to explore the robustness of our results, we start in column (1) with a specification that contains basic variables such as the log-number of designated countries, the number of non-identical IPC classifications, the grant lag, a PCT application dummy and the log-number of claims. We then add various other variables, such as the number of forward and backward citations (column (2)), variables characterizing the crowdedness of technical subfields and their interaction with the applicants' portfolios (column (3)) and finally technical subfield and type of owner dummy variables (column (4)). In column (5) we explore in some detail the impact of the various types of references to the patent literature. We substitute for the aggregate variable four variables which are computed from the number of A-, X-, Y- and other references. In columns (1) to (5), we report the probit coefficients and their respective standard errors. In column (6) we compute the marginal effects of the independent variables at the sample mean based on the coefficients displayed in column (5).

With very few exceptions[42], our probit results do not change much as we add additional variables. We therefore turn directly to columns (4) and (5) for our discussion, and we refer to the marginal effects and their standard errors displayed in column (6) when we discuss the impact of the

[42] In column (2), the coefficient of ln(total number of claims) is much smaller than in column (1) due to the fact that citations cause a missing variables problem in (1). The coefficient of the scope variable introduced by Lerner (1994) – initially insignificant - becomes significantly negative as we incorporate citation and other exogenous variables. Going from column (3) to column (4), the coefficient of the crowdedness variable (the cumulative, i.e., time-variant number of patent applications in a subfield) becomes insignificant as we introduce dummy variables for technical subfields. This is due to the dominance of cross-sectional variation in the crowdedness variable. Finally, the PCT variable is no longer statistically significant one we add citation variables in column (2) that include those citations that are made by the EPO in its function as the World Intellectual Property's (WIPO) international search authority (see also footnote 34). In the other cases, the coefficients and their standard errors remain stable as we add additional variables.

exogenous variables on the likelihood of opposition. In column (5), we also document heteroskedasticity-robust estimates of the standard errors in brackets. However, since these are (as in the other specifications) very close to the standard errors from the classical probit estimates, we do not discuss them in detail. They simply serve to demonstrate that the inference results we are discussing are robust to this potential source of misspecification. The standard errors reported for the marginal effects are derived from the standard variance-covariance matrix of the probit estimator.

The estimated coefficients for our primary set of variables introduced in column (1) behave as expected. An increase in the number of designated countries from the sample mean of 10.4 to 14.0 (a shift of about one standard deviation) increases the likelihood of opposition by 1.0 percentage points. Since increasing the number of countries with patent protection causes the cost of patenting to rise, we interpret this result as support for our third hypothesis. Adding 1.5 years (one standard deviation) to the grant lag is associated with a significant increase in the opposition frequency of 1.1 percentage points, consistent with our notion that complex patents are likely to take more time to be examined, and that the opponent is subject to an informational disadvantage with respect to such patents. Contrary to our expectations, patents granted as Euro-PCT applications do not face a significantly higher likelihood of opposition than non-PCT applications. An increase in the total number of claims from the sample mean of 13.8 to 25 claims (again a shift of about one standard deviation) is accompanied by an increase in the rate of opposition of 1.0 percentage points. As we noted before, an increase in the number of claims adds to the complexity of patents and may lead opponent and patent holder to have either divergent views or asymmetric information in assessing the outcome of the opposition case.

The scope variable introduced by Lerner (1994) does not appear to be an indicator of value – its coefficient is not positive as the original interpretation would suggest, but significantly less than zero. Moreover, its marginal effect (a reduction in opposition frequency 0.4 percentage points for an increase by one standard deviation) is quite small. These results resemble those obtained in a study of U.S. patent litigation by Lanjouw and Schankerman (2001), but are in contrast with Lerner's (1994) study which reports a positive correlation between scope and the market value of the biotechnology firms owning the respective patents.

The number of citations received from subsequent EPO patent applications (in logarithms) proves to be a very important predictor of opposition. Recall that the average number of citations is 1.32, and that only 54.7 percent of all patents receive any citations (see Table 2). The first citation is associated with an increase of the likelihood of opposition by 3.4 percentage points, (estimated with a standard error of about 0.3 percentage points), the first five citations with an increase of 8.8 percentage points. The coefficient of references to the nonpatent literature is not significant and very close to zero in all specifications. This is somewhat surprising since Harhoff, Scherer and Vopel (2003) detect clear evidence for German patents that a strong correlation exists between these references and patent value. A possible explanation of our results in Table 7 would be that the increase in value documented by a large number of nonpatent literature references is accompanied by an increase in the legal “robustness” of the patent right. While increased value may help to make opposition look attractive to competitors, the links to scientific results may reduce the chances of a successful outcome of the challenge. We will investigate this explanation in future work.

However, the number of references to the patent literature is informative about the likelihood of opposition – the respective coefficient is positive, but – looking at column (4) – only about one fifth of the size of the forward citations coefficient. The effect of this measure is almost exclusively driven by one component – the number of X-type references. Once we decompose the overall number of patent references into its four subgroups in column (5), it becomes clear that increasing the number of X-type references is associated with a significant increase in the opposition rate: for the first X-type reference by 1.2 percentage points, and for an increase from 0 to 5 such references by 3.0 percentage points. Since we are controlling for the patent’s value in our probit specifications, this effect appears to be due to the opponent’s increased difficulty in interpreting the information in the search report and patent correctly. As the patent applicant has an advantage here, the opponent is likely to face less precise information, or the existence of X-type references favors the emergence of diverging expectations regarding the outcome of the opposition case. Our results demonstrate that the WIPO classification of cited documents in the research report could become an interesting variable for empirical researchers interested in modelling litigation or the value of patent rights. To the best of our knowledge, this information has not been used before.

We have argued that interactions between patent holders in "crowded" fields with a large cumulative number of patents should lead to an increase in the rate of opposition, since competitors are more likely to pursue similar research paths. At the same time, opposition by competitors is likely to be a function of the patent holder's portfolio. We model these effects by including a measure for “crowdedness”, a measure for the size of the patent portfolio of the firm holding the opposed patent, and the interaction term. “Crowdedness” has the anticipated positive marginal effect on opposition (see column (6)), but it is quite small and only works through the interaction term.[43] For firms with the average number of patents (29.9 patents), an increase in the number of patents in the technical field by 1,000 patents raises the likelihood of opposition by 0.11 percentage points. For firms with exceptionally strong patent portfolios (e.g., 300 patents), the effect is on the order of 1.2 percentage points. The effect of the firm's own portfolio is much larger. Adding 100 patents to the average portfolio of 29.9 patents in a technical field with about 2,500 patents reduces the rate of opposition by 1.8 percentage points. Again, the effect is highly significant. This effect is even stronger in less densely populated areas due to the positive interaction of crowdedness and

[43] See Bernhardt and Jung (1979) for a discussion of how to compute effect sizes from interaction terms in in a regression framework..

portfolio effects – in a technical field with 1,000 patents the marginal effect from an addition of 100 patents to the average portfolio is a reduction of the opposition rate by 2.3 percentage points. These results parallel the evidence in Lanjouw and Schankerman (2001) who find in their study of U.S. patent litigation cases that litigation is more likely to occur whenever patents appear to form the basis of a sequence of technologically linked inventions.

We hypothesized that patents in fields with higher economic, legal or technical uncertainty and subsequently higher asymmetry of information should attract opposition more frequently than areas with little uncertainty. These expectations are confirmed in our estimates. The joint test for significance of those variables characterizing the IPC classification of the patent yield a strong result (χ^2=25.2, df=5) – clearly, there are important differences across these groups. Taking the group C12M (apparatus for enzymology or microbiology) as our reference case, we would expect all other IPC groups included in our study (see Table 2 for a description) to display higher opposition rates. The C12M classification refers to patented machinery which may be much closer in terms of the patented inventions to mechanical engineering fields than to recombinant DNA biotechnology. Our estimates show that the strongest increment in opposition rates occurs in the IPC fields C12N (microorganisms or enzymes – 8.4 percentage points, S.E. 2.8) and C12P (fermentation or enzyme-using processes – 8.4 percentage points, S.E. 3.2). Classical pharmaceuticals (A61K, without cosmetics) face an opposition rate that is only 6.5 percentage points (S.E. 1.9) higher than patents in the reference group. The dummy variables for the other two IPC classes (C12Q and C07G) carry positive coefficients which are statistically insignificant. Note that these two groups are quite small (see Table 1) so that the lack of precision in the estimated coefficients is not entirely surprising. In total, the estimated dummy coefficients conform quite well to our theoretical expectations.

Finally, we do not find robust evidence that patents held by individual inventors are more likely to be challenged, *ceteris paribus*. This would be the case if financially strong corporations try to attack independent inventors in order to prevent them from commercializing their intellectual property. But the estimated coefficient is negative in column (5) and insignificant. This result can be maintained even when the crowdedness and portfolio size variables are excluded from our specification. In this case (as in the results in column 6), the marginal effect associated with the dummy variable inventor applicant amounts to –1.3 percentage point, and again it is not significant (S.E 0.8). It is important to note that even in this specification there is no indication that individual inventors (irrespective of the size of their patent portfolio) are more likely to face opposition than corporate entities.

The coefficients for the nationality of the owner do not display a clear pattern, but they are highly significant (χ^2= 47.3, df=7). Taking German applicants as the reference group, applicants from the Great Britain, Switzerland and a residual group of smaller countries do not face incrementally different opposition rates. Japanese owners have a significantly lower rate of opposition (by 3.8

percentage points, S.E. 0.9), and US and French owners face somewhat lower opposition rate (by 1.7 (S.E. 0.6) and 1.9 (S.E. 0.8) percentage points). The first result is consistent with earlier evidence in Harhoff, Scherer and Vopel (2003) who point out that Japanese-owned German patents with priority year 1977 were less likely to be opposed at the German Patent Office in an institutional setting very similar to that at the EPO. Presumably, this reflects the high quality of the patent specifications. But in general, it is difficult to interpret the inventor country coefficients clearly. On the one hand, patents of foreign applicants not coming from EPC countries are likely to face higher costs for obtaining intellectual property than applicants in EPC countries. Hence, the patent rights pursued at the EPO would on average be of higher value, leading us to expect a positive coefficient. On the other hand, these applicants may also have higher costs in pursuing opposition proceedings, thus increasing the chance of an *ex ante* settlement with the opponent. The overall effect would be ambiguous, and absent more precise cost data, we cannot empirically separate the overlapping effects.[44]

We finally report briefly on further specification tests we undertook.[45] We estimated the specification in column (5) for a sample of patent holders with a patent stock of at least nine patents in order to test the robustness of our results. For this subsample of patent applicants with relatively stable patenting activity, we found very similar results in which the significance levels were maintained for all but one of the variables – the coefficient of the "applicant inventor" dummy is close to zero and insignificant. This is due to the fact that there are only very few independent inventors with more than nine patent grants. Since we rely on particular functional form assumptions, we also tested if the use of logarithmic transformations for the number of designated countries, citations and claims variables is justified on statistical grounds. Reestimating column (5) with all of these variables in linear form actually yields a somewhat weaker result than shown in Table 7, with a log-likelihood of –3,590.9 and a pseudo-R-squared of 0.088. Using both linear and logarithmic terms in the nested probit function also yields results in favor of the logarithmic specifications.[46] The marginal effects reported in the paper are only weakly affected by the choice of functional form, and we maintain the results as shown in columns (5) and (6) as our preferred specification.

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44 All specifications in Table 7 include dummy variables for grant years. Jointly, the coefficients of these are highly significant (χ^2=84.4, df=15 in column 5). The estimated grant year coefficients are available on the journal's web pages.

45 These estimation results are again available on the journal's web pages.

46 For example, including the number of A, X, Y and other backward citations both in linear and logarithmic form yields a test statistic of χ^2= 11.06 (df=4, p=0.026) for the logarithmic and χ^2= 4.44 (df=4, p=0.350) for the linear terms. Not surprisingly, the linear and logarithmic terms are highly collinear; thus the significance levels of each group is reduced by the presence of the other set of regressors.

6 Conclusions and Further Research

This paper has presented an empirical analysis of the opposition procedure at the European Patent Office in the technical fields of biotechnology and pharmaceuticals. To the best of our knowledge, this is the first econometric study of its kind. The previous lack of interest cannot be attributed to the fact that the topic is unimportant – from 1995 to 1999 the EPO granted a total of 235,396 patents, and 14,087 of these patents (5.98%) were opposed. We emphasized that it is important to characterize the function of this mechanism: opposition may serve a valuable function in weeding out weak patents or in resolving legal uncertainty with regard to particularly valuable inventions.

We developed a highly stylized theoretical model in section 3 of this paper. From our model and the literature we developed four hypotheses which focused on the value of the patent right, the degree of uncertainty and asymmetric information surrounding the patent, the impact of diverging expectations and the implications of cost differentials for opposition and settlement. Empirically, we find that correlates of patent value such as received citations and the number of countries for which the EPO patent is designated are relevant predictors of the likelihood of opposition. Moreover, uncertainty and asymmetric information appear to play a role as suggested by theoretical models of case selection for trial: in certain new technical areas as delineated by the IPC classification, the likelihood of opposition is considerably larger than in more mundane areas. Patents which are presumably characterized by intensive discussions between examiners and applicants (e.g., patents with a large number of claims and a high number of X-type references to the patent literature as well as patent with long grant lags) also face a much higher risk of opposition – we attribute this to the pronounced informational asymmetries facing the opponents of these patents or to the divergence of expectations emerging in this complex informational setup.

While the overall results are encouraging, we need to acknowledge that the current study has a number of shortcomings. First, due to data constraints we cannot test a structural model, but are confined to testing hypotheses in a reduced-form equation. Moreover, and again due to data constraints, it is not feasible to separate clearly between all of our hypotheses. To do so, we would need data on the cost structure of opponents and patent holders which is not available at this stage. A third limitation is that we do not consider the overall chain of challenges that are conceivable – since there is (to the best of our knowledge) no dataset that covers both opposition and litigation stages in the battle for intellectual property. While the latter problem is serious, we nonetheless think that analyzing a legal institution that concerns roughly ten times as many cases as litigation does has some merit and is informative. But it needs to be acknowledged that there is room for improving these estimates as new data sources are becoming available.

This study is therefore a first analysis of an important institution, and more structured attempts, both for particular technical fields and the population of patents, should follow. Moreover, it will be important to study the duration of the opposition process – if the process is used strategically by some opponents to create legal uncertainty about the status of a patent right, we should be able to detect a pattern in which these cases take longer to be resolved, even after accounting for observable differences in the potential value of the patent rights. The question of who opposes whom is of similar interest – again, a pattern of frequent attacks of small or young firms by established players would be a worrisome result. If cases are indeed selected strategically, we may be able to find an analogue of Lerner's (1998) observation that "patenting in the shadow of infringement" leads start-up firms in the biotechnology sector to patent in niches in which a legal conflict with large players is unlikely to occur. Currently, the results from this study do not support this view, since we find that individual patent holders (inventor applicants) are *not* more likely than corporations with respect to their opposition incidence.

Finally, we should also emphasize that the opposition procedure is not used only by competitors of patent applicants. In particular in the field of biotechnology, a large number of public interest groups and non-governmental organizations is trying to influence European patenting practice by filing opposition cases against certain patents. It should be interesting to study the political economy of this process as well as the detailed structure of the institution in further work.

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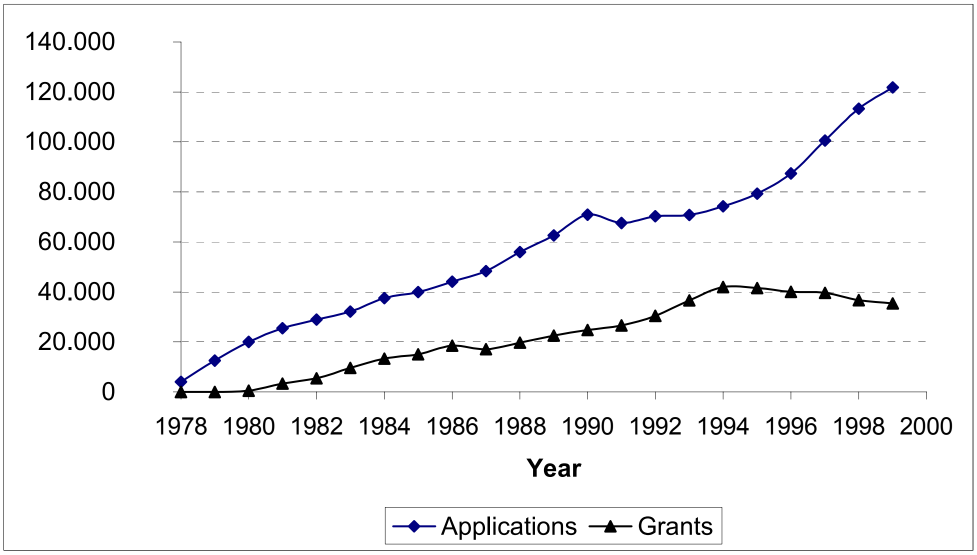
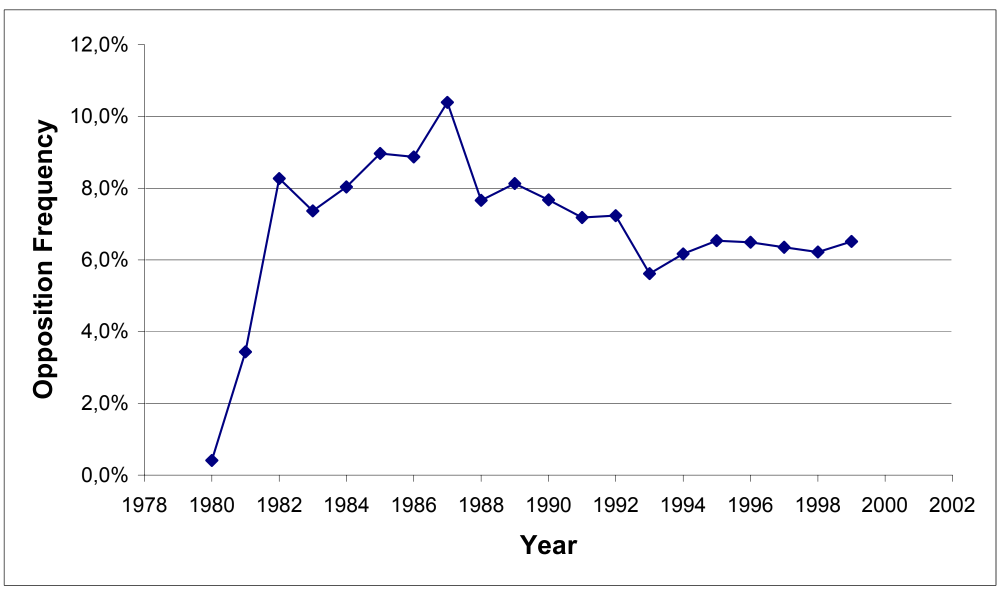
Figure 1
EPO Applications and Patent Grants
1978-1999



Source: European Patent Office Annual Report 1999, Table 7.6

Figure 2
Opposition Frequency
1978-1999



Note: Opposition frequency is computed as the number of patents opposed divided by the number of all patents granted in a given year. The first EPO patents were issued in 1980.

Source: European Patent Office Annual Report 1999, Table 7.6

Figure 3

Parameter Combinations (p,Π^{D}) in the Theoretical Model

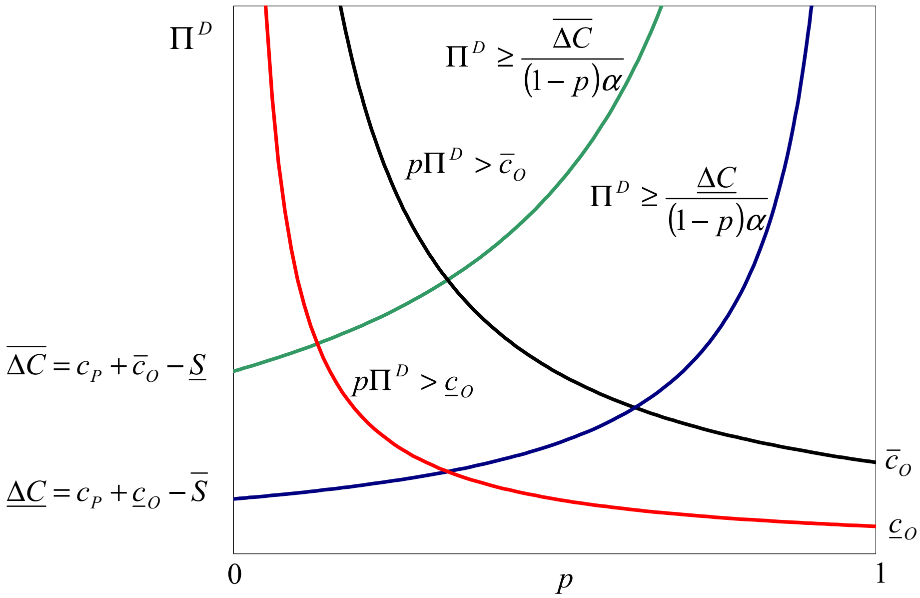


Table 1
Descriptive Statistics for the Biotechnology
and Pharmaceuticals Sample
(N=13,389)

Variable	Mean	S.D.	Min.	Max.
opposition case (0/1)	0.0864		0	1
number of designated states	10.445	3.437	1	17
number of non-identical IPC classifications	1.934	1.936	1	23
grant lag (years)	4.886	1.517	1.345	13.208
PCT application (0/1)	0.253	-	0	1
number of claims	13.622	11.235	1	274
number of citations received	1.319	2.051	0	47
number of nonpatent references	2.078	2.538	0	31
total number of patent references	3.120	2.578	0	57
number of A-type patent references	0.757	1.585	0	43
number of X-type patent references	0.912	1.933	0	19
number of Y-type patent references	0.601	1.503	0	15
number of other patent references	0.851	1.902	0	29
crowdedness (cumulative number of patents within four-digit IPC/1000)	2.486	2.144	0.001	7.394
size of applicant's patent portfolio (cumulative number of patents by patent holder/1000)	0.030	0.049	0.001	0.341
IPC A61K – preparation for medical, dental, or toilet purposes (0/1)	0.552		0	1
IPC C07G – compounds of unknown constitution (0/1)	0.009		0	1
IPC C12M – apparatus for enzymology or microbiology (0/1)	0.030		0	1
IPC C12N – microorganisms or enzymes; composites thereof (0/1)	0.215		0	1
IPC C12P – fermentation or enzyme-using processes (0/1)	0.110		0	1
IPC C12Q – measuring or testing processes involving enzymes (0/1)	0.083		0	1
inventor applicant (0/1)	0.065		0	1
owner from U.S. (0/1)	0.338		0	1
owner from Great Britain (0/1)	0.074		0	1
owner from France (0/1)	0.067		0	1
owner from Japan (0/1)	0.191		0	1
owner from Switzerland (0/1)	0.025		0	1
owner from other country (0/1)	0.115		0	1

Table 2

Forward Citations and Incidence of Opposition

Number of Forward Citations	Number of Observations	% of Total Observations	Incidence of Opposition – All Patents	Incidence of Opposition – Patents of U.S. Owners		Incidence of Opposition - Patents of JP Owners		Incidence of Opposition - Patents of Other Owners	
			Mean	Obs.	Mean	Obs.	Mean	Obs.	Mean
0	6,060	45.27	0.053	1,757	0.055	1,182	0.026	3,121	0.062
1-3	5,976	44.63	0.092	2,109	0.095	1,180	0.054	2,687	0.106
4-6	971	7.25	0.176	441	0.186	157	0.070	373	0.209
7-9	263	1.96	0.235	132	0.235	30	0.133	101	0.267
>9	119	0.89	0.445	80	0.437	7	0.429	32	0.469
Total	13,389	100.00	0.086	4,519	0.098	2,556	0.044	6,314	0.095
χ^2			454.51		206.60		44.45		186.59
(p-value)			(<0.001)		(<0.001)		(<0.001)		(<0.001)

Note: The χ^2 statistics (and p-values) refer to a Pearson test of the hypothesis that there is no relationship between the number of forward citations and the incidence of opposition within the indicated group of patents.

Table 3

Backward Citations and Incidence of Opposition

Number of Backward Citations	Number of Observations	% of Total Observations	Incidence of Opposition – All Patents	Incidence of Opposition – Patents of U.S. Owners		Incidence of Opposition - Patents of JP Owners		Incidence of Opposition – Patents of Other Owners	
			Mean	Obs.	Mean	Obs.	Mean	Obs.	Mean
0	1,531	11.43	0.084	517	0,112	289	0,048	725	0,079
1-3	6,993	52.23	0.078	2,299	0.094	1,386	0.039	3,308	0.083
4-6	3,728	27.84	0.093	1,227	0.100	707	0.040	1,794	0.110
7-9	843	6.30	0.119	322	0.093	132	0.091	389	0.149
>9	294	2.20	0.129	154	0.123	42	0.119	98	0.143
Total	13,389	100.00	0.086	4,519	0.098	2,556	0.044	6,314	0.095
χ^2			27.06		2.95		13.76		28.39
(p-value)			(<0.001)		(0.566)		(0.008)		(<0.001)

Note: The χ^2 statistic (and p-value) refer to a Pearson test of the hypothesis that there is no relationship between the number of backward citations and the incidence of opposition within the indicated group of patents.

Table 4

References to the Nonpatent Literature and Incidence of Opposition

Number of References to the Non-Patent Literature	Number of Observations	% of Total Observations	Incidence of Opposition – All Patents	Incidence of Opposition – Patents of U.S. Owners		Incidence of Opposition - Patents of JP Owners		Incidence of Opposition - Patents of Other Owners	
			Mean	Obs.	Mean	Obs.	Mean	Obs.	Mean
0	4,514	33.71	0.087	1,493	0.085	735	0.050	2,286	0.099
1-3	6,023	44.98	0.078	1,870	0.086	1,322	0.047	2,831	0.087
4-6	2,097	15.66	0.088	764	0.106	417	0.031	916	0.098
7-9	528	3.95	0.144	246	0.195	68	0.015	214	0.126
>9	227	1.70	0.172	146	0.199	14	0.000	67	0.149
Total	13,389	100.00	0.086	4,519	0.098	2,556	0.044	6,314	0.095
χ^2			48.90		49.41		4.61		7.48
(p-value)			(<0.001)		(<0.001)		(0.330)		(0.113)

Note: The χ^2 statistic (and p-value) refer to a Pearson test of the hypothesis that there is no relationship between the number of references to the nonpatent literature and the incidence of opposition within the indicated group of patents.

Table 5

European Familiy Size and Incidence of Opposition

Number of Designated States	Number of Observations	% of Total Observations	Incidence of Opposition – All Patents	Incidence of Opposition – Patents of U.S. Owners		Incidence of Opposition - Patents of JP Owners		Incidence of Opposition – Patents of Other Owners	
			Mean	Obs.	Mean	Obs.	Mean	Obs.	Mean
1-4	1,154	8.62	0.030	277	0.039	659	0.023	218	0.041
5-10	4,109	30.69	0.083	1,165	0.104	1,115	0.056	1,829	0.085
11-14	7,334	54.78	0.100	2,832	0.104	715	0.048	3,787	0.101
>14	792	5.92	0.062	245	0.065	67	0.015	480	0.067
Total	13,389	100.00	0.087	4,519	0.098	2,556	0.044	6,314	0.095
χ^2			70.02		15.50		12.71		19.54
(p-value)			(<0.001)		(0.001)		(0.005)		(<0.001)

Note: The χ^2 statistic (and p-value) refer to a Pearson test of the hypothesis that there is no relationship between the number of designated states and the incidence of opposition within the indicated group of patents.

Table 6
Correlation Matrix for Metric Variables in the Probit Models

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
(1)	ln(number of designated countries)l	1.000													
(2)	number of non-identcal IPC classifications	-0.000	1.000												
(3)	grant lag (years)	-0.023	0.136	1.000											
(4)	ln(number of claims)	0.128	0.217	0.224	1.000										
(5)	ln(1+number of citations received)	0.066	0.132	0.202	0.254	1.0000									
(6)	ln(1+number of nonpatent references)	0.026	0.085	0.221	0.085	0.097	1.000								
(7)	ln(1+number of patent references)	0.003	-0.011	0.008	0.105	0.065	-0.202	1.000							
(8)	ln(1+number of A-type references)	-0.040	-0.006	-0.074	-0.042	-0.055	-0.085	0.211	1.000						
(9)	ln(1+number of X-type references)	0.053	-0.017	0.079	0.083	0.054	-0.032	0.375	-0.220	1.000					
(10)	ln(1+number of Y-type references)	0.032	-0.060	0.018	0.013	0.016	0.011	0.281	-0.170	-0.123	1.000				
(11)	ln(1+number of other references)	-0.051	0.071	0.022	0.078	0.070	-0.084	0.293	-0.274	-0.245	-0.222	1.000			
(12)	crowdedness	0.321	-0.149	-0.213	-0.026	-0.080	-0.058	0.068	0.024	0.127	0.078	-0.140	1.000		
(13)	size of applicant's patent portfolio	0.084	0.009	-0.066	-0.056	-0.018	-0.001	-0.029	0.027	0.026	0.005	-0.093	0.168	1.000	
(14)	crowdedness*size of applicant's patent portfolio	0.141	-0.058	-0.141	-0.045	-0.040	-0.033	0.007	0.012	0.061	0.016	-0.085	0.433	0.802	1.000

Note: N=13,389. Pearson product-moment correlation coefficients.

Table 7
Probit Models of Opposition

Independent Variable	(1) Coefficient (S.E.)	(2) Coefficient (S.E.)	(3) Coefficient (S.E.)	(4) Coefficient (S.E.)	(5) Coefficient(S.E.)		(6) Marg. Effect (S.E.)
ln(number of designated countries)	0.371**	0.342**	0.319**	0.219**	0.214**		0.028**
	(0.047)	(0.048)	(0.048)	(0.050)	(0.050)	[0.049]	(0.007)
number of non-identical IPC classifications	-0.016	-0.027**	-0.021*	-0.029**	-0.029**		-0.004**
	(0.008)	(0.009)	(0.009)	(0.009)	(0.009)	[0.009]	(0.001)
grant lag (years)	0.084**	0.056**	0.079**	0.057**	0.051**		0.007**
	(0.011)	(0.012)	(0.014)	(0.017)	(0.017)	[0.017]	(0.002)
PCT Application	0.085*	0.073	0.052	0.051	0.044		0.006
	(0.039)	(0.040)	(0.041)	(0.042)	(0.043)	[0.041]	(0.006)
ln(total number of claims)	0.223**	0.137**	0.137**	0.130**	0.126**		0.016**
	(0.025)	(0.026)	(0.026)	(0.027)	(0.027)	[0.028]	(0.004)
ln(1+number of citations received)		0.367**	0.372**	0.379**	0.375**		0.049**
		(0.025)	(0.025)	(0.025)	(0.025)	[0.026]	(0.003)
ln(1+number of nonpatent references)		0.012	0.022	0.016	0.012		0.002
		(0.023)	(0.023)	(0.024)	(0.024)	[0.024]	(0.003)
ln(1+number of patent references)		0.071**	0.063*	0.078**			
		(0.026)	(0.026)	(0.027)			
ln(1+number of A-type references)					-0.053		-0.007
					(0.035)	[0.036]	(0.005)
ln(1+number of X-type references)					0.128**		0.017**
					(0.028)	[0.028]	(0.004)
ln(1+number of Y-type references)					0.052		0.007
					(0.033)	[0.033]	(0.004)
ln(1+number of other references)					0.063*		0.008*
					(0.031)	[0.031]	(0.004)
crowdedness			0.040**	-0.003	-0.003		0.0011**
			(0.014)	(0.023)	(0.023)	[0.023]	(0.0004)
size of applicant's patent portfolio			-1.987**	-2.439**	-2.421**		-0.183**
			(0.762)	(0.795)	(0.797)	[0.771]	(0.071)
crowdedness*size of applicant's patent portfolio			0.320*	0.425*	0.412*		
			(0.171)	(0.176)	(0.177)	[0.166]	

Table 7
Probit Models of Opposition (continued)

Independent Variable	(1) Coefficient (S.E.)	(2) Coefficient (S.E.)	(3) Coefficient (S.E.)	(4) Coefficient (S.E.)	(5) Coefficient (S.E.)		(6) Marg. Effect (S.E.)
IPC A61K (pharmaceuticals - without cosmetics)				0.521**	0.506**		0.065**
				(0.152)	(0.152)	[0.148]	(0.019)
IPC C07G (compounds of unknown constitution)				0.169	0.188		0.028
				(0.257)	(0.256)	[0.259]	(0.043)
IPC C12N (microorganisms or enzymes;				0.523**	0.519**		0.084**
composites thereof)				(0.144)	(0.144)	[0.139]	(0.028)
IPC C12P (fermentation or enzyme-using				0.481**	0.491**		0.084**
processes)				(0.146)	(0.147)	[0.142]	(0.032)
IPC C12Q (measuring or testing processes				0.244	0.251		0.038
Involving enzymes)				(0.149)	(0.149)	[0.145]	(0.026)
Inventor applicant				-0.104	-0.103		-0.013
				(0.072)	(0.072)	[0.071]	(0.008)
US patent owner				-0.136**	-0.137**		-0.017**
				(0.049)	(0.049)	[0.048]	(0.006)
GB patent owner				0.070	0.068		0.009
				(0.066)	(0.066)	[0.066]	(0.009)
FR patent owner				-0.166*	-0.163*		-0.019*
				(0.076)	(0.077)	[0.077]	(0.008)
JP patent owner				-0.331**	-0.337**		-0.038**
				(0.061)	(0.062)	[0.062]	(0.006)
CH patent owner				0.096	0.091		0.013
				(0.098)	(0.098)	[0.102]	(0.015)
other patent owner				-0.063	-0.066		-0.008
				(0.061)	(0.061)	[0.061]	(0.007)
Constant	-2.699**	-2.583**	-2.598**	-2.719**	-2.649**		-
	(0.166)	(0.171)	(0.172)	(0.220)	(0.220)	[0.172]	-
log L	-3771.85	-3652.53	-3639.22	-3601.61	-3588.44		
Pseudo R2	0.0429	0.0732	0.0765	0.0861	0.0894		
chi-squared	338.1	526.7	603.3	678.6	704.9		

Note: N=13,389 - * significant at 5%; ** significant at 1%. All specifications include additional dummy variables for grant years.
Heteroskedasticity-robust standard errors are printed in brackets in column (5).