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Why Challenge the Ivory Tower? New Evidence on the Basicness of Academic Patents

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and Cédric Schneider

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Non-technical Summary

Historically universities used to generate knowledge that was made available to the public at no further cost, as the research was financed by the government, and thus by a country's tax paying inhabitants. The emergence of private universities and new laws on intellectual property rights changed the common practice, though. While the main activities of universities remain education and academic research that is disseminated through journal publication activity, commercial activities are on the rise in public science. For instance, the U.S. Bayh-Dole Act from 1980 enables universities (and small business) to claim property rights through patent filings even if the underlying research was financed by public money. This trend poses the question whether universities still contribute significantly to the amount of basic science produced in an economy when becoming commercially active. While journal publications are certainly targeting basic research questions, the content of academic patens is not unambiguously of basic nature. If universities would move to more applied research, this could have detrimental effects for total welfare in the economy. While often presumed in academic literature and policy discussions there is little empirical evidence showing that academic patents protect more basic inventions than corporate patents.

This study provides new evidence on the basicness of academic patents using professor patents for Germany linked to patent opposition data from the European Patent Office (EPO). Patent oppositions are the most important mechanism by which the validity of patents filed at the EPO can be challenged. We argue that academic patents should be less likely to be subject to validity challenges if they are more basic than corporate patents. Disputes about the validity of intellectual property rights, as patent litigations and patent oppositions, have been interpreted by the scientific literature as a legal mechanism to enhance patent quality and the effectiveness of the patent system and as an indication for competition. In this paper, we follow the latter interpretation. Previous literature has revealed that patents themselves are rather strategic tools for firms than instruments for intellectual property protection. This evidence supports the interpretation of legal disputes over patent validity as an indication for competition in product and technology markets. Basic inventions, which are not immediately directed at a marketable product, are less likely to threaten

the current competitive position of companies than more applied inventions as they are less likely to threat other firms' position in product markets.

In our empirical analysis, we find that academic patents are opposed less frequently than a control group of corporate patents. This suggests that academic patents cover rather basic inventions with a low immediate commercial value not threatening current returns of potential patent opposers in the corporate sector. The effect is weaker for academic patents in collaboration with the business sector, which suggests that those patents are evaluated as more applied or threatening by the business sector.

Das Wichtigste in Kürze (Summary in German)

Traditionell waren die an Universitäten und öffentlichen Forschungseinrichtungen hervorgebrachten Forschungsergebnisse der Allgemeinheit frei zugänglich, da sich diese Institutionen durch öffentliche Steuergelder finanzieren. In den letzen Jahren hat sich die Forschungslandschaft jedoch grundlegend gewandelt. Private Universitäten und Änderungen in der Rechtslage betreffend universitäres geistiges Eigentum habe dazu ein wesentliches beigetragen. Während Lehre und Forschung auch weiterhin den Schwerpunktbereich der universitären Aktivität darstellen, haben Universitäten in den letzten Jahren damit begonnen, aktiv ihre Forschung gewinnbringend zu vermarkten. Vorreiter waren die US amerikanischen Universitäten, denen nach einer Gesetzesänderung im Jahre 1980, dem sogenannten Bayh-Dole Act, der Universitäten (und kleinen Industrieunternehmen) die Eigentümerschaft an den hervorgebrachten Erfindungen zugesprochen hat, obwohl diese mit öffentlichen Steuergeldern finanziert wurden.

Dieser Kommerzialisierungstrend an Universitäten wirft die Frage auf, ob sich das Wesen der universitären Forschung in den letzten Jahren grundlegend gewandelt hat: hat eine Hinwendung der traditionell im Bereich der Grundlagenforschung anzusiedelnden Universitätsforschung zu angewandter Forschung mit kommerziellem Fokus stattgefunden? Eine solche Entwicklung könnte schwerwiegende Folgen für die volkswirtschaftliche Wohlfahrt in der langen Frist haben.

Diese Studie widmet sich der Fragestellung nach dem Charakter der universitären Forschung. Anhand einer Stichprobe von akademischen Patenten, die von Hochschulprofessoren entwickelt and am Europäischen Patentamt (EPA) angemeldet wurden, gehen wir der Frage nach, ob diese Erfindungen eher in den Bereich der Grundlagenforschung fallen als eine Kontrollgruppe von patentierten Erfundungen aus der freien Wirtschaft.

Dabei stützen wir unsere Analyse auf ein dem EPA eigenen Einspruchsverfahren, demzufolge die Neuigkeitsanforderungen von Patentanmeldungen durch Dritte angezweifelt werden können. Dieses Verfahren wird in der Regel von Wettbewerbern in Anspruch genommen, die ihren Marktanteil sichern wollen. Sollten Universitätserfindungen dementsprechend eher „Forschung“ als kommerzialisierbare

„Technologie“ schützen, würden wir erwarten, dass gegen solche Patente seltener Einspruch erhoben wird.

Die wissenschaftliche Literatur präsentiert solche Einspruchsverfahren gegen die Neuigkeitsanforderungen von Patentanmeldungen als juristische Instrumente zur Verbesserung der Qualität von Patentanmeldungen und zur Steigerung der Effizienz des Patentsystems. Eine andere Sichtweise der akademischen Forschung stellt Einspruchsverfahren gegen Patente als einen Wettbewerbsindikator dar. Vor dem Hintergrund, dass Patente selbst of als strategische Waffe gegen Wettbewerber genutzt werden, ist es einsichtig, dass auch Einspruchsverfahren gegen Patente zu diesem Zweck eingesetzt werden können. Dieser Argumentation folgend, zeigt unsere empirische Studie auf, dass akademische Patente seltener ins Fadenkreuz von Wettbewerbern geraten als Patente der Industrie. Die Tatsache, dass es weniger Einspruchsverfahren gegen akademische Patente gibt, interpretieren wir als einen Indikator für deren Grundlagenforschungscharakter. Besonderes Augenmerk verdient letztendlich die Heterogenität der universitären Forschung: währen rein akademische Patente weniger Einspruchsverfahren anziehen, gilt dies nicht für akademische Erfindungen, die durch die freie Wirtschaft patentrechtlich geschützt werden. Das zeigt deutlich, dass die gegenwärtige universitäre Forschung ein breites Spektrum von angewandter bis hin zu Grundlagenforschung abdeckt.

Why Challenge the Ivory Tower?
New Evidence on the Basicness of Academic Patents

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Abstract

While often presumed in academic literature and policy discussions there is little empirical evidence showing that academic patents protect more basic inventions than corporate patents. This study provides new evidence on the basicness of academic patents using German professor patents linked to patent opposition data from the European Patent Office (EPO). Patent oppositions are the most important mechanism by which the validity of patents filed at the EPO can be challenged. Controlling for patent value, asymmetric information and diverging expectations between the opposition parties, the likelihood of a potentially litigious situation and the relative costs of opposition versus settlement, we find that academic patents are opposed less frequently than a control group of corporate patents. This suggests that academic patents cover rather basic inventions with a low immediate commercial value not threatening current returns of potential plaintiffs. The effect is weaker for academic patents in collaboration with the business sector, which suggests that those patents are evaluated as more applied by owners of potentially rival technologies.

Keywords: academic inventors; intellectual property rights; patent oppositions

JEL-Classification: O31, O32, O34

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1 Introduction

The assumption that patents produced in the public sector are more basic than corporate patents is often made in academic literature and policy discussions, e.g. on the financing of science (Mansfield, 1995), on economic growth (Adams, 1990, Caballero and Jaffe, 1993) or the interaction between science and the government (Stokes, 1997). There is however surprisingly little empirical evidence showing that academic research is indeed more basic than corporate research.

This paper makes a contribution to the empirical literature on basicness of academic research. So far, empirical studies mostly assume that academic research is more basic rather than providing actual tests on this assumption. An exception is an article by Trajtenberg et al. (1997), in which the authors suggest patent-based proxies for the basicness of patented research. In particular, forward citations and a generality index turn out to be useful proxies for basicness.[1] Since then these proposed measures have been widely used in empirical research, especially for the analysis of knowledge diffusion (e.g. Jaffe et al., 1993, Stolpe, 2001, Thursby et al., 2007). This paper takes a different approach to show that academics patents are more basic. Based on a sample of German academic patents and a control group of corporate patents at the European Patent Office (EPO) we investigate the probability for academic patents to be subject to patent oppositions. Patent oppositions are the most important mechanism by which the validity of patents filed at the EPO can be challenged (Harhoff and Reitzig, 2004). The study is, to the best of our knowledge, the first paper that explicitly tests for the basicness of academic patents with European data.

We argue that academic patents should be less likely to be subject to validity challenges if they are more basic than corporate patents. Disputes about the validity of intellectual property rights, as patent litigations and patent oppositions, have been interpreted by the scientific literature as a legal mechanism to enhance patent quality and the effectiveness of the patent system (Cockburn et al., 2002, Graham et al., 2003, Harhoff and Reitzig, 2004) or as an indication for competition (Lanjouw and

[1] Forward citations are references made to the patent by future patent filings. The generality index is based on forward citations. It is a Herfindahl index of concentration whereby the number of citations in each three-digit patent class plays the same role as the sales of each firm in the traditional industrial organization context (Trajtenberg et al., 1997).

Schankerman, 2001, 2004, Somaya, 2003). In this paper, we follow the latter interpretation. Previous literature has revealed that patents themselves are rather strategic tools for firms than instruments for intellectual property protection (Levin et al., 1987, Cohen et al., 2000, Arundel et al., 1995). Using a recent survey of German firms that explicitly focuses on strategic motives of patenting, Blind et al. (2007) find that 40 percent of all patent applications are meant to block competitors. Firms engage particularly in defensive blocking, as a forward-looking protection strategy directed at protecting their position in technology markets. This evidence supports the interpretation of legal disputes over patent validity as an indication for competition in product and technology markets. Basic inventions, which are not immediately directed at a marketable product, are less likely to threaten the current competitive position of companies than more applied inventions as they are less likely to threat other firms' position in product markets.

In our empirical analysis on the probability of academic patents to become subject to validity challenges, we control for the main determinants that have been identified by the theoretical literature (Cooter and Rubinfeld, 1989) and approved by empirical studies (Lanjouw and Schankerman, 2001, Harhoff and Reitzig, 2004), namely the patent value, asymmetric information and diverging expectations between the conflict parties, the likelihood of a potentially litigious situation, and the cost of the challenge relative to the costs of settlement. Keeping all these factors constant our results reveal that academic patents are less likely to be subject to a validity challenge than corporate patents. We interpret this finding as evidence for the basicness of inventions protected by academic patents as compared to corporate patents. Distinguishing between academic patents assigned to corporations and the public science sector reveals that only the patents assigned to the public sector are less likely to be opposed. Academic patents assigned to the business sector face statistically the same likelihood of opposition than purely corporate patents. This supports our interpretation that purely academic patents are more basic and for this reason less likely to be challenged.

The remainder of the paper is organized as follows. The next section gives an overview on the institutional background relevant for patent oppositions at EPO. Section three reviews the literature on patent oppositions and derives our conceptual framework. Section four introduces our data sample. In section five the empirical analysis is shown and section six concludes.

2 Patent applications and oppositions at the EPO: Institutional Background

The EPO was founded in 1978 as the result of the European Patent Convention (EPC). Within this framework, a single and centralized application is made, allowing applicants to choose the jurisdictions among the contracting states of the EPC in which protection is sought for.

EPO patents are issued for inventions that are novel, involve an inventive step and are commercially applicable. After the application to the EPO, a search report is issued in which examiners list the state of prior art regarded as relevant for the patentability of the invention, by referring to prior patents and to the non-patent literature. It is worthwhile to mention that contrary to patentee at the USPTO, EPO applicants do not have the "duty of candor" in the sense that they are not requested to provide a list of prior art, as this is the responsibility of a search examiner.

If a European patent is granted, competence is transferred to the designated contracting states, where it affords the same level of legal protection as a national patent and is valid for 20 years from the date of (first) filing if it is consecutively renewed. Therefore, after being granted, a European patent becomes a bundle of national rights implying that applicants will have to enforce the patent in each national jurisdiction. Infringement lawsuits may be filed before a civil court in each national jurisdiction, once the patent becomes effective in the designated states through legal means allowed for by the respective national patent law. If the patent is found invalid in one country, this is not binding in the other jurisdiction designated in the original application.

However, up to nine months after the announcement of the grant, an EPO patent can be opposed centrally by any third party. Analogous to the granting decision, the outcome of the opposition procedure is binding in all jurisdictions designated in the application. An opposition may only be filed on grounds relating to the patentability of the invention (EPC art. 100) and therefore excludes infringement lawsuits. In other words, the plaintiff will have to demonstrate that the patent lacks novelty, does not involve an inventive step, does not have an industrial application or that disclosure is insufficient.

The opposition procedure differs from patent litigation suits with regard to the settlement possibilities. Once an opposition is filed, the EPO may continue its investigation of the case so that the opponents are not always able to settle outside the court once an opposition is filed. Hence, settlement should take place before the opposition case is filed. Hall et al. (2003) recommend the introduction of an opposition system for the US, where at the moment patents can only be challenged through litigations, as it is supposed to be associated with substantial welfare gains.
This section is based on more detailed surveys of the European Patent Office (EPO) opposition system as provided by Harhoff and Reitzig (2004) and Harhoff (2005).

3 Determinants of Patent Oppositions

The theoretical literature on legal disputes and their resolution is summarized by Cooter and Rubinfeld (1989).[2] The main predictions from the theoretical models on legal disputes can be taken forward to the case of patent litigations (Lanjouw and Lerner, 1989, Lanjouw and Schankerman, 2001) and patent oppositions (Harhoff and Reitzig, 2004). Harhoff and Reitzig (2004) and Hall and Harhoff (2002) show that the main theoretical predictions for patent oppositions can be derived from a simplified version of Priest's and Klein's (1984) model:

- Prediction 1: The probability of opposition increases in the likelihood of a potentially litigious situation occurring or being detected by the plaintiff.
- Prediction 2: The probability of opposition increases in the information asymmetries or divergence in parties' expectations about the outcome of the trial.
- Prediction 3: The probability of opposition increases in the cost of trial relative to the cost of settlement.

[2] Later theoretical research elaborates mainly on the assumption asymmetric information. Waldfogel (1998) reviews this later theoretical and empirical literature in his discussion on asymmetric information and divergent expectations.

- Prediction 4: The probability of opposition increases in the size of the stakes i.e. the value of the patent and any indirect benefit from filing a case, e.g. expected enhancement of reputation and bargaining power in the future.

There are a few recent studies investigating the determinants of patent validity challenges in the US and Europe.[3] Lanjouw and Schankerman (2001) study the incidence of patent litigation in the US. Somaya (2003) investigates the determinants of patent litigation in the U.S. computer and medical research sector. Harhoff and Reitzig (2004) analyze the determinants of patent opposition in Europe and Hall and Harhoff (2002) investigate opposition behavior in the European cosmetics industry. Reitzig (2004) investigates whether institutional aspects of the patent process and determinants of the patent application file impact patent oppositions in the European chemical industry. A comparison of the US litigation system and the European opposition system is carried out by Graham et al. (2003). The empirical studies mentioned above broadly confirm the predictions from the theoretical literature.

Prediction 1: The probability of opposition increases in the likelihood of a potentially litigious situation occurring or being detected by the plaintiff.

A plaintiff goes forward with a trial rather than agreeing on settlement if she expects to win something from the defendant. If there is some indication that the patent in question is weak this should increase her incentive to proceed to an opposition case. Lanjouw and Schankerman (2001) interpret this prediction as “any action that could be considered as an infringement of patent rights”. The patent application procedure at the EPO provides some useful information to identify potentially litigious patents (Harhoff and Reitzig, 2004). As described above for each patent application a search report is published, which can contain interesting information for potential opponents as it lists the references made to prior art indicating which of those threaten the novelty of the patent in question. There is positive evidence for patents with many novelty threatening backward citations to be more often subject to oppositions. Note that the interpretation of the novelty threatening references is hence twofold: on the one hand they might hint at patents for which an opposition has a larger chance to go

[3] The earlier empirical literature on patent litigations is summarized by Lanjouw and Lerner (1989).

through; on the other hand they might map information asymmetries between potential opponents (see next subsection).

Prediction 2: The probability of opposition increases in the information asymmetries or divergence in parties' expectations about the outcome of the trial.

Two major theories exist to explain the occurrence of patent litigations (Waldfogel, 1998): the theory of asymmetric information between the parties involved in the dispute (e.g. Bebchuk, 1984) and the theory of divergent expectations (e.g. Priest and Klein, 1984). The two models differ mainly on their prediction on the outcome of the trial: under the assumption of diverging expectations the victory rate should be 50% for each party, whereas the likelihood to win should be higher for the defendant under the assumption of asymmetric information. The prediction for an incidence of patent validity challenges is not different under both assumptions (Harhoff and Reitzig, 2004). Hence, we tackle them together in our empirical model as in Harhoff and Reitzig (2004) and Lanjouw and Schankerman (2001).[4]

Empirical studies typically assume that the presence of both asymmetric information and diverging expectations is more likely in new technology fields as those are characterized by a higher economic, legal and technical uncertainty (Lanjouw and Schankerman, 2001, Harhoff and Reitzig, 2004). A small number of references to prior art in patents is interpreted as an indication for a relative new technology field or a niche field, which is associated with higher uncertainties. Another measure for diverging expectations or asymmetric information is the grant lag, i.e. the time it takes the patent examiners from the patent application to the grant decision. Further, a longer time span mirrors a higher complexity of the underlying technology (Harhoff and Reitzig, 2004). Harhoff and Reitzig (2004) find that the effect of backward citations is mainly driven by those references that threaten the novelty of the patent application in question. They state that the number of those references in the search report is indication for asymmetric information. The authors argue that the evaluation of the references in the search report is preliminary and subject to further negotiation between the patent applicant and the patent examiner. Potential opponents are assumed to have access to the information in the search report. They have no

[4] See Waldfogel (1998) for an empirical test on both assumptions for the outcome of federal civil cases.

information on the progress of the negotiation between patent application and examiner, though. Hence, Harhoff and Reitzig (2004) argue that the number of novelty threatening references in the search report will increase the uncertainty of the potential opponent about the outcome of the patent application and increase asymmetric information between patent application and potential opponent. Their results confirm that patents with many novelty threatening backward citations are more likely to be subject to an opposition (see also Hall and Harhoff, 2002 and Reitzig, 2004). As a further measure for asymmetric information and diverging expectations Harhoff and Reitzig (2004) use the number of claims a patent protects. Whereas Lanjouw and Schankerman (2001) use this measure as a patent value correlate Harhoff and Reitzig (2004) argue that this aspect of claims cannot be distinguished from the asymmetric information and diverging expectations argument. Most empirical studies find empirical evidence for higher opposition rates in technologies characterized by a higher legal, technical and economic uncertainty, which again confirms the prediction of the theoretical models.

Prediction 3: The probability of opposition increases in the cost of trial relative to the cost of settlement.

The relative cost of trial versus settlement is relatively difficult to account for in empirical studies as there is typically no data available to proxy this difference in costs. Lanjouw and Schankerman (2001) and others use indirect measures like the litigation probability of domestic versus foreign patent applicants and the litigation probability of individuals that apply for patents versus corporations. There is broad evidence for corporations having lower settlement costs than individuals and also higher strategic incentives to litigate. In a similar vein, the patent portfolio of the parties involved has been used as an indication for the relative settlement costs. Lanjouw and Schankerman (2001) and Harhoff and Reitzig (2004) argue that a large patent portfolio makes settlement more likely as there are more options to settle via licensing contracts. Somaya (2003) takes citations from the patent owner to the opponent into account to control for settlement options through licensing. Moreover, a large patent portfolio diminished the impact of a successful validity suit for defendants and plaintiffs.

Prediction 4: The probability of opposition increases in the size of the stakes i.e. the value of the patent and any indirect benefit from filing a case,

e.g. expected enhancement of reputation and bargaining power in the future.

The more a party can win in a trial as compared to the settlement outcome the more likely it will not settle. The size of the stake in patent validity challenges is typically proxied by measures for the patent value as the number of claims and the number of citations a patent receives by future patents. Further, patent families for US studies and the number of designated states or PCT filings for EPO patents (Harhoff and Reitzig, 2004) have been used as value correlates as they show a broader geographical protection of an invention (Putnam, 1996, Lanjouw, 1998). Further, competition-based measures for patent value as the "crowdedness" of a technology field are used, i.e. the number of backward citations. Somaya (2003) and Lanjouw and Schankerman (2001) further use self-citation measure to control for the importance of a technology for the patent holder. There is strong empirical evidence for a positive relationship between those patent value correlates and the probability of a validity challenge. For a more extensive list of patent value correlates used in the patent litigation and opposition context see Table 1 in Reitzig (2004).

Indications for Patent Basicness in Previous Studies on Patent Validity Challenges

There are also some patent value-based measures that turn out to have no impact on the litigation or opposition rate in empirical studies or even show up significantly with the an unexpected coefficient sign. One of these measures is the "breath" of the patent (Lerner, 1994). Patents protecting inventions that are relevant for many different technology classes are supposed to be relevant for a larger product space and might hence attract more potential opponents. This hypothesis does not find empirical support in most studies.[5]

A second patent value correlate that does not show the expected effect on the occurrence of litigations and oppositions is non-patent references in patents. References to non-patent literature indicate linkages to the scientific, rather basic research and are found to have a higher scientific quality of the patent (Meyer, 2000, Callaert et al., 2004). Harhoff et al. (2003) show that patents citing non-patent references have a higher monetary value in the German chemical and pharmaceutical

[5] An exception is Somaya (2003) on the U.S. computer and medical research sector.

industries. However, Harhoff and Reitzig (2004) and Hall and Harhoff (2002) do not find a significant relationship between non-patent references and the opposition rate. Reitzig (2004) even reports evidence for a negative relationship between patent oppositions and non-patent references in the European chemical industry. Harhoff and Reitzig (2004) explain their finding with a potentially higher “legal” robustness that coincides with non-patent references, which reduces the expected chances of a positive opposition outcome for the opponent. Reitzig (2004) admits that non-patent references might be a noisy measure for the scientific link of the patent in questions as there is a high variation within non-patent references (Meyer et al., 2003). Callaert et al. (2004) however show that roughly 65% of NPRs in EPO patents refer to scientific publications and there is some recognition of their use as an indicator of science-technology linkages (Meyer, 2000, Schmoch, 1997).

Apart from the explanations for the unexpected findings given by the authors, patent breadth as well as references to non-patent literature could also have a different interpretation. A negative impact of patent breadth on opposition rates would hint at those patents being “more general and, therefore, has less immediate relevance for market outcomes“ (Harhoff and Reitzig, 2004). A similar effect could be expected from strongly science-based patents as they are supposed to have less immediate commercial value as well.

The contribution of this paper

We exploit these indications of basicness patents in studies of patent validity disputes and investigate whether there is evidence for academic patents being more basic, as apparent in lower opposition rates, than corporate patents. Our data set allows controlling for non-patent references and patent breadth as well as for the main predictions of the theoretical literature.

Previous literature shows that patents produced by universities (Henderson et al., 1998) or by firms with strong scientific ties (Cassiman et al., 2008) generate more forward citations. Hence, scientific involvement in inventive activities results in greater knowledge externalities and more “important” patents. However, we know very little about the nature of these inventions. Going beyond citation counts, we will test whether patents that involve academic inventors are more or less likely to be opposed than those of the controls. An opposition procedure at the EPO, as described in Section 2, can only be filed on grounds relating to the patentability of an invention, mainly the novelty and inventive step requirements. Therefore, this procedure provides a unique opportunity to assess the novelty and inventive step of patented inventions *as perceived by* owners of potentially rival technologies. If patents that involve academic inventors contain more complex, fundamental and truly novel knowledge, in other words, if academic inventors patent science rather than technologies (Sampat et al., 2003), any potential application of this knowledge (at the date of grant) will still be far from the market and therefore not easily diffused and consequently less likely to draw opposition from potential competitors.

Furthermore, we overcome a limitation of most literature on academic patents. While the literature has found an increase in university patenting over time, van Pottelsberghe (2007) points out that this can only be seen as a lower bound. The adoption of the Bayh-Dole Act in 1980 enabled U.S. public research institutions (and small firms) to claim intellectual property rights of inventions even if the underlying research was financed by public resources. Although several European countries have adopted similar U.S. style legislations, this happened much later than in 1980, for instance, in the U.K. in 1998, in Belgium in 1999, in Denmark in 2000, in Germany and Austria in 2002 (see van Pottelsberghe, 2007: 184-185). In Germany, for example, the so-called professors' privilege allowed professors to patent their inventions until 2002 privately without university involvement. As a consequence, most academic inventions where patented by individuals or firms, and not by universities. As most statistics on academic patenting rely on categorizing the applicant as "academic" or not, numbers on the contribution of universities to technology development are highly underestimated (as we will document in the next section). We overcome this limitation, as we have collected "academic patents" through inventor records. We searched for academic inventors irrespectively of the applicant. Furthermore, we use this important detail of the data collection to investigate the basicness of patents in more detail. Our data will allow to differentiate between academic patents and different categories of applicants, especially the distinction between purely academic patent (inventor is a professor and applicant is a public research institution or the professor himself) and academic patents that result from consulting industry partners, i.e. the inventor is a professor but the patent is filed by a firm (see Thursby et al., 2009, for further evidence on faculty consulting). If the presumption holds that academic patents are more basic than corporate patents (in combination with the established incentives for patent oppositions), we expect that academic patents are opposed least frequent and corporate patents are opposed most. However, academic inventors that file a patent with a corporation as applicant will be opposed more than pure academic patents, as the underlying consulting activity of the academic can be expected to be of more applied nature with direct impacts on competing intellectual property rights and (technology) markets, than potentially more basic purely university research-based inventions.

4 Data and Variables Definitions

4.1 Data and sample selection

Our analysis is based on a database issued by the European Patent Office (EPO) and the OECD. The "EPO/OECD patent citations database" covers all patents applied for at the EPO since its foundation in 1978 and up to October 2006 as well as all patents applied for under the Patent Cooperation Treaty (PCT) in which the EPO is designated, so-called "Euro-PCT applications". In addition to detailed information on all patents and their citations, the dataset contains other information for each patent (technology classes, date of application and title) and each applicant and inventor (name and place of residence). An earlier version of this database is fully described and analyzed in Webb et al. (2005).

From this database we extracted all applications involving at least one inventor residing in Germany, resulting in a total of 346,892 patent applications. We identified all patents invented by German Professors by using the persons' title "Prof. Dr." and variations of that. The professor title is protected by the German criminal code (article 132a) against misuse by unauthorized persons. Although not compulsory, it is common practice in Germany to use academic titles in official communications. Czarnitzki et al. (2007) conducted a test on the accuracy of this identification strategy for German Patent and Trademark Office (GPTO) and the EPO. They checked whether the names of professors appeared in the patent database without the title but with the same address in order to verify that the title field is always filled in the data. The verification of a sample of persons had shown that university professors (or professors at other higher education facilities such as polytechnical colleges) can be identified by their title with high precision. Czarnitzki et al. (2007) conclude that it basically never happens that inventor names appear sometimes with “Prof. Dr.” (or similar title) and sometimes without on other patents. Thus, we can safely argue that with focus on Germany this procedure delivers a listing of patents where professors are recorded as inventors. In total, we found 4,973 (granted) patents that list at least one faculty member between 1980 and 2003. Our data turned out to contain “only” 22 university patents (i.e. patents owned by universities), roughly 0.45% of the total of academic patents.

To further check the completeness of our sample of academic patents, we compared the outcome with a similar search in the data from the GPTO. More precisely, we searched all patent applications that have an EPO equivalent at the GPTO and that list professors as inventors. We found only 112 applications in which the GPTO patent listed a professor, but not the equivalent EPO patent over the period 1990-2001.

In order to analyze opposition behaviour towards those “academic patents”, we constructed a control group that includes one non-academic patent for each academic patent. The non-academic patents were randomly drawn based on the date of applications and on 30 patent technology classes as defined in the OST-INPI/FhG-ISI classification also often referred to as the Fraunhofer classification, which is based on a concordance with IPC assignments. For a detailed description see OECD (1994: 77-78).

In order to ensure that no academic patent would end up in our control group, we deleted patents granted to non-German universities and public non-university research institutions[6] from the pool of non-academic patents. In total, 6,758 patents were taken out of the pool from which the control group was drawn.

The opposition data is taken from the European Patent Bulletin provided by the EPO. This data source provides a complete listing of all oppositions filed at EPO including the names of the plaintiff, opposition date and the outcome of the validity challenge.

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[6] This required a manual search in all assignee names. Most prominent examples of German public research institutions are the Max-Planck Society, the Fraunhofer Society and the Helmholtz Society. However, the search was not limited to those. We excluded all public non-profit research institutions from the control group.

4.2 Variables

We use two different dependent variables in our multivariate analysis. The first one is a dummy that takes on the value one if the focal patent was opposed at the EPO, and zero otherwise. The second one is the number of oppositions filed against each patent. While the bulk of opposed patents face only one plaintiff, some face several of them.

Our main variable of interest is the involvement of an academic inventor in the creation of a patented technology. Therefore, we define a binary variable indicating whether an academic is listed as inventor (see description in Section 4.1). Furthermore, we distinguish between different types of assignees. Academic patents can be assigned to a corporation, to the scientific sector (the academic inventor him/herself or to a public research institute or to a university). There is a significant share of European academic inventions that go directly to the business sector and are patented by corporations. Lissoni et al. (2008) estimate that the share of academic inventions patented outside academe is between 60% and 80%. These patents cover mainly consulting activities of the faculty (Thursby et al., 2007, Goddar, 2005). Therefore, we expect those patents to be more applied than other academic inventions, which would result in a lower probability of being opposed and a lower number of oppositions per patent. We further have a residual group of assignees, which cover all patent owners that are neither corporations nor public research institutions nor the academic inventor. These represent mainly government institutions, non-academic individuals, foundations etc.

Following the theoretical literature on endogenous disputes and previous empirical studies on patent litigation and opposition (summarized in Section 3), we control for several attributes that may lead to higher expected likelihood of opposition. We hypothesize that the remaining variation in the likelihood of opposition stems from the novelty of the patented invention (as perceived by potential competitors), once all these effects are netted out.

The number of backward citations: The search report published by the EPO yields information on the state of the art relevant for a given patent application. Backward citations determine the legal boundaries of an invention by citing a related body of work. Thus, one could hypothesize that applications containing references to a large number of related inventions are of more incremental. However, empirical evidence tends to uncover a positive effect of backward citations on the value of a patent (Harhoff et al., 2003), which suggests that the number of cited patent is more likely to refer to the extent of patenting in a given technological area (Lanjouw and Schankerman, 2001) and hence to the potential profitability of inventions falling into that domain. Everything else equal, patents in more crowded areas should be opposed more often.

Share of X and Y backward citations: Backward citations at the EPO are classified into different categories by the examiner during the search procedure, according to their relevance for the evaluation of patentability of the invention. Two interesting categories for our purpose are:

- "Type X" citations. References classified in this category indicate material that is potentially harmful to the novelty or inventive step requirements of the claimed invention, when the referenced document is taken alone.
- "Type Y" citations indicate material that is potentially harmful to the inventive step requirement of the claimed invention, when the referenced document is combined with one or more other documents of the same category, such a combination being obvious to a person skilled in the art.

We include the sum of X and Y citations, relative to the total number of backward citations. This measure is presumably (inversely) correlated with the degree of novelty and/or inventive step of the claimed invention and a high share of those critical references is therefore likely to attract the attention of potential plaintiffs. Moreover, as noted by Harhoff and Reitzig (2004), there is likely to be informational advantage on the side of the patent owner in the presence of X and Y citations. Therefore, patents having large share of X and Y citations are likely to generate asymmetric information and diverging expectations.

The number of forward citations is defined as the number of citations received by a focal patent from any subsequent patent application and measures the “importance”, the “quality” or the “significance” of a patented invention. Previous studies have shown that forward citations are highly correlated with the social value of the patented invention (Trajtenberg, 1990, for the computer tomography industry) as well as with its private value (Harhoff et al., 1999, Hall et al., 2005). Furthermore, forward citations reflect the economic and technological “importance” as perceived by the inventors themselves (Jaffe et al., 2000) and knowledgeable peers in the technology field (Albert et al., 1991). In this paper we use citation data from the EPO that has been made recently available in machine readable format by the EPO and the OECD. The high correlation between the number of forward citations to EPO patents with patent value has been documented by Gambardella et al. (2008).

The likelihood of opposition is expected to increase with the economic and technological importance of a given patent, as the size of the stakes increase for both parties.

We also include the *share of forward X and Y citations*, which accounts for the potential blocking power of a given patent. If a patent is listed as an X or Y reference in subsequent patents, it means that the owner of the original patent can potentially block the development of follow-on research by (potential) competitors (Hall and Harhoff, 2001, Guellec et al., 2008). This type of patents have been found to be of particular interest for firms acquiring technology portfolios (Grimpe and Hussinger, 2008a,b). Hence, we expect that patents with a blocking potential are also more likely to be challenged by competitors.

The grant lag (in years) measures the time elapsed between the dates of grant and application of a focal patent. The duration of the examination procedure is, among other things, influenced by the complexity of the invention and the intensity of negotiations between the examiner and the applicant (Harhoff and Wagner, 2005). Therefore, the probability of litigation is expected to increase with the grant lag, as longer pendencies will lead to asymmetric information and diverging expectations.

Non-patent references (NPR) indicate that the examiner inserted at least one citation to the non-patent literature into the search report. While the meaning of NPRs is not unambiguous, they are can be considered a approximation of a patent's scientific linkage. There is some evidence that citing many NPRs coincide with a higher patent value (see Harhoff et al., 2003 for the case of chemicals and pharmaceuticals), therefore increasing the stakes for both parties, patents in emerging technology areas which would lead to asymmetric information between both parties (Lanjouw and Schankerman, 2001), or inventions resulting from fundamental research and thus further away from market applications. The first two interpretations suggest that

NPRs may increase the likelihood of opposition, while the third interpretation suggests a negative partial correlation.

Patent scope: Following Lerner (1994), we use the number of international patent classes (IPC), at the 4-digit level, assigned to the patent as a measure of patent scope. The number of IPC assignments is a proxy for the extent of monopoly power a patent grants. Thus, the broader the scope of a patent, the higher the expected likelihood of opposition.

Number of inventors: The number of inventors serves as a further proxy for the scope of the patented invention.

Technology classes: We include 30 technology class dummies since some technologies, especially in emerging fields, might by nature be more likely to be opposed.

Grant year: Finally, we also include dummies for each grant year, to control for any remaining unobserved economic fluctuation over time.

4.3 Descriptive statistics

Table 1 provides an overview of the variables used in the multivariate analysis. Several patterns stand out from the comparison of academic and non-academic patents. Academic patents are less likely to be opposed than non-academic patents. Academic patents also face a lower average number of oppositions. Regarding the control variables, academic patents receive, on average, more citations than the control group. The mean share of forward X and Y citations suggests that academic patents have a greater blocking potential compared to non-academic patents. In addition, academic patents contain more NPRs, appear to be broader, as measured by the number of IPC assignments and to be in less crowded technology fields as indicated by the number of backward citations. The average grant lag suggests that academic patents face longer pendencies.

Table 2 presents the descriptive statistics for academic patents with different class of owners. The figures reveal that academic patents assigned to Public Research Institutes (PRI) have the lowest opposition rate, while academic patents assigned to corporations have the highest share of opposition.

Table 1: Descriptive statistics: academic versus non-academic patents

	Academic patents				Non-academic patents			
	Mean	S.D.	Min	Max	Mean	S.D.	Min	Max
Opposition	0.075	0.263	0	1	0.091	0.287	0	1
# of oppositions	0.093	0.382	0	6	0.116	0.422	0	7
# Forward citations	3.119	4.061	0	58	2.514	3.240	0	48
Forward citations=0	0.223	0.416	0	1	0.265	0.441	0	1
Share of X & Y forward citations	0.177	0.283	0	1	0.146	0.275	0	1
# Backward citations	3.568	2.366	0	19	3.809	2.238	0	18
Backward citations=0	0.052	0.221	0	1	0.028	0.164	0	1
Share of X & Y backward citations	0.248	0.356	0	1	0.227	0.340	0	1
Grant lag (in years)	4.058	1.456	1	14	3.863	1.355	1	13
NPR	0.371	0.483	0	1	0.250	0.433	0	1
# IPC assignments	1.679	0.861	1	11	1.571	0.771	1	8
# inventors	3.438	2.071	1	21	2.576	1.624	1	12
Observations	3860				3860			

Table 2: Descriptive statistics of academic patents by applicant type

	Academic patents with corporate assignee				Academic patents with academic assignee				Other academic patents			
	Mean	S.D.	Min	Max	Mean	S.D.	Min	Max	Mean	S.D.	Min	Max
Opposition	0.076	0.265	0	1	0.073	0.261	0	1	0.070	0.256	0	1
# of oppositions	0.096	0.391	0	6	0.086	0.346	0	5	0.070	0.256	0	1
# Forward citations	3.127	4.172	0	58	3.133	3.557	0	24	2.860	3.519	0	24
Forward citations=0	0.230	0.421	0	1	0.192	0.394	0	1	0.198	0.401	0	1
Share of X & Y forward citations	0.186	0.288	0	1	0.134	0.248	0	1	0.197	0.321	0	1
# Backward citations	3.453	2.289	0	19	3.983	2.568	0	17	4.279	2.949	0	15
Backward citations=0	0.053	0.225	0	1	0.047	0.212	0	1	0.047	0.212	0	1
Share of X & Y backward citations	0.251	0.359	0	1	0.236	0.341	0	1	0.245	0.353	0	1
Grant lag (in years)	4.014	1.431	1	13	4.283	1.524	1	12	4.081	1.703	1	14
NPR	0.376	0.485	0	1	0.366	0.482	0	1	0.349	0.479	0	1
# IPC assignments	1.687	0.847	1	11	1.646	0.918	1	6	1.651	0.808	1	4
# inventors	3.684	2.101	1	21	2.482	1.635	1	12	2.872	1.570	1	11
Observations		3092				724				86		

5 Empirical Results

Table 3 reports the regression results of the probit model on patent opposition. The first column reports the result of a probit estimation where we regress the binary indicator of opposition on our academic dummy, as well as on the controls. In the second column we split the academic dummy according to the type of assignee.

As expected, academic patents are less likely to draw oppositions, since the invention underlying the patent will in most cases still be far away from market applications. This is in line with our hypothesis that academic patents cover rather fundamental and scientific inventions that are further away from market application. Given their fundamental and complex nature the technological content takes a longer time to diffuse (Sampat et al., 2003). Therefore, academic patents are less threatening to potential competitors and are less likely to face oppositions.

When we distinguish between the three types of assignees, we find that academic patents assigned to corporations do not significantly differ from patents in the control group (i.e. purely corporate patents). Conversely, academic patents assigned to the scientific sector exhibit a negative and significant effect, suggesting that they embed more fundamental knowledge than the control group and than other academic patents. The test of equality of the three academic assignment dummies reported at the bottom of Table 3 rejects the null hypothesis (at the 10% level) confirming a heterogeneous impact of academic patents on the likelihood to face opposition.

The control variables have the expected signs and are consistent both with the theoretical literature on legal disputes outlined in Section 3 and with prior literature on patent opposition and litigation. More important patents as measured by forward citations appear to be more frequently opposed, as the theory would suggest. In addition, the occurrence of oppositions increases with the blocking potential of the patent (share of X and Y forward citations). The same effect applies to the number of backward citations, notably on those pointing to critical references (share of X and Y backward citations), thereby confirming the results of Harhoff and Reitzig (2004). The scientific linkage of the patent, measured through NPRs, decreases the occurrence of opposition, but appears to have no effect on the number of oppositions filed against a given patent. The proxies for patent scope, i.e. the number of IPC assignments and the number of inventors on a patent, have a negative impact on the likelihood of an opposition. This is in line with the view that these variables measure the degree of complexity of an invention. It stands in contrast to the interpretation that patents with a broader scope, as measured by IPC assignments and size of the inventor team, are supposed to attract potential plaintiffs from various different fields. The grant lag seems to have no significant impact on the occurrence and number of oppositions.

Table 3: Estimation results – probit model of patent opposition

Variables	Coeff.		std. err.	Coeff.		std. err.
Academic patent	-0.119	***	0.045			
-w. corporate assignee				-0.063		0.048
-w. academic assignee				-0.239	***	0.079
-w. other type of assignee				-0.289		0.216
# Forward citations	0.047	***	0.005	0.047	***	0.005
# Forward citations=0	-0.165	***	0.064	-0.170	***	0.064
Share of forward X & Y citations	0.173	**	0.081	0.165	**	0.081
# Backward citations	0.013		0.010	0.014		0.010
# Backward citations=0	0.047		0.141	0.042		0.142
Share of backward X & Y citations	0.189	***	0.065	0.186	***	0.065
Grant lag	0.020		0.017	0.022		0.018
NPR	-0.104	*	0.056	-0.104	*	0.056
# IPC assignments	-0.054	*	0.029	-0.054	*	0.029
# inventors	-0.034	**	0.014	-0.039	***	0.014
Constant	-0.642	*	0.389	-0.640	*	0.389
Appl. years - test on joint significance	χ^2 (20)=31.11**			χ^2 (20)=31.62**		
Tech. classes - test on joint significance	χ^2 (28)=135.38 ***			χ^2 (28)=137.81 ***		
Test on equality of coef. of assignment variables				χ^2 (2)=5.06*		
# observations	7720					

Notes: *** (**, *) indicate a significance level of 1% (5%, 10%).

Next, we use the extent of opposition to a given patent as dependent variable in order to test the robustness of our results. We estimate the model using both Poisson and Negative Binomial regressions. The Poisson model is estimated by Quasi-Maximum Likelihood (QML), since estimates of this model will be consistent, provided the mean is correctly specified, even if the true distribution is not Poisson (Gouriéroux et al., 1984). However, it is possible to improve efficiency by making more restrictive assumptions about the way the variance differs from the mean, which is why we also report results of Negative Binomial regressions. The Hausman test reported at the bottom of Table 5 does not reject the Negative Binomial Model.

Table 4: Estimation results – Poisson QML estimation of the count of oppositions

Variables	Coeff.		std. err.	Coeff.		std. err.
Academic patent	-0.221	***	0.090			
-w. corporate assignee				-0.102		0.095
-w. academic assignee				-0.523	***	0.163
-w. other type of assignee				-0.727	*	0.400
# Forward citations	0.069	***	0.007	0.068	***	0.007
# Forward citations=0	-0.424	***	0.130	-0.439	***	0.130
Share of forward X & Y citations	0.259	*	0.138	0.237	*	0.139
# Backward citations	0.032	*	0.017	0.034	**	0.017
# Backward citations=0	0.114		0.287	0.109		0.286
Share of backward X & Y citations	0.400	***	0.128	0.396	***	0.128
Grant lag	0.004		0.035	0.009		0.035
NPR	-0.121		0.121	-0.121		0.121
# IPC assignments	-0.081		0.059	-0.080		0.059
# inventors	-0.051	*	0.030	-0.061	**	0.031
Constant	-0.719		0.635	-0.720		0.636
Appl. years - test on joint significance	χ^2 (20)=31.95**			χ^2 (20)=31.95**		
Tech. classes - test on joint significance	χ^2 (28)=117.03 ***			χ^2 (28)=117.03***		
Test on equality of coef. of assignment variables				χ^2 (2)=7.70**		
# observations	7720					

Notes: *** (**, *) indicate a significance level of 1% (5%, 10%).

The results of the count models confirm our previous finding. First, academic patents face a lower probability to be legally attacked at the EPO. Second, the results confirm the differences between the different types of organizations that own academic patents. Academic patents owned by corporations are not significantly different from the control group, whereas academic patents assigned to the scientific sector face less oppositions. The test of equality of the three academic dummies rejects again the null hypothesis, but at the 5% level this time.

The sign of the controls does not differ much from the results of the probit analysis. The number of backward citations becomes positively significant, whereas the number of IPC assignments become insignificant.

Table 5: Estimation results – Negative Binomial estimation of the count of oppositions

Variables	Coeff.		std. err	Coeff.		std. err
Academic patent	-0.261	***	0.088			
-w. corporate assignee				-0.143		0.094
-w. academic assignee				-0.555	***	0.159
-w. other type of assignee				-0.767	*	0.464
# Forward citations	0.094	***	0.011	0.094	***	0.011
# Forward citations=0	-0.325	**	0.131	-0.336	**	0.131
Share of forward X & Y citations	0.291	*	0.159	0.278	*	0.160
# Backward citations	0.031	*	0.019	0.033	*	0.019
# Backward citations=0	0.094		0.278	0.077		0.278
Share of backward X & Y citations	0.418	***	0.126	0.412	***	0.126
Grant lag	0.005		0.034	0.010		0.035
NPR	-0.082		0.108	-0.078		0.108
# IPC assignments	-0.069		0.056	-0.069		0.056
# inventors	-0.056	**	0.027	-0.067	**	0.027
Constant	-0.854		0.683	-0.854		0.681
Overdispersion parameter	2.602	***	0.307	2.558	***	0.303
Appl. years - test on joint significance	χ^2 (20)=34.61**			χ^2 (20)=35.42**		
Tech. classes - test on joint significance	χ^2 (28)=123.97***			χ^2 (28)=127.71***		
Test on equidispersion	χ^2 (1)=226.35***			χ^2 (1)=222.97***		
Generalized Hausman test[§]	χ^2 (59)=38.77			χ^2 (60)=40.43		
Test on equality of assignment variables				χ^2 (2)=7.25**		
# observations	7720					

Notes: *** (**, *) indicate a significance level of 1% (5%, 10%).
The generalized Hausman test compares the negative binomial models with the Poisson estimates, and does not reject the Negative Binomial regressions.

6 Conclusion

This study provides evidence on the basicness of academic patents. That academic patents protect more basic and more fundamental inventions than corporate patents is often taken for granted in the academic literature. There is only very little evidence that this is actually the case (e.g. Trajtenberg et al., 1997). This study provides some further justification for this common presumption.

Our study is based on patent oppositions as a measure for competition in product markets (Lanjouw and Schankerman, 2001, 2004, Somaya, 2003). Previous literature has shown that particularly valuable patents are more likely to be opposed because those promise a higher profit for the inventor in case of a patent grant and a higher profit for the plaintiffs in case of patent rejection (Harhoff and Reitzig, 2004). An immediate implication is that academic patents would be expected to receive less oppositions in case they would indeed be more basic and hence further away from direct market applications than corporate patents.

Based on a sample of patents invented by German professors and a control group of corporate patents we test whether there are differences in opposition occurrence and frequency for both types of patents. Our empirical analysis supports that academic patents receive less oppositions than corporate patents, which we interpret as an indication for their relative basic and fundamental nature.

In order to provide further support for this conclusion we distinguish between academic patents assigned to the public sector and to corporations. Patents assigned to the business sector represent typically consulting activities of faculty members (Goddar, 2005, Thursby et al., 2007). Accordingly, they should be closer to industrial applications and receive more oppositions. Our results confirm that academic patents assigned to the corporate sector are as likely to be opposed as corporate patents. This strongly supports our interpretation of purely academic patents being more basic and fundamental than corporate patents.

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