JENA ECONOMIC RESEARCH PAPERS

2009 – 068

University Patenting in Germany before and after 2002: What Role Did the Professors´ Privilege Play?

by

Sidonia von Ledebur
Guido Buenstorf
Martin Hummel

www.jenecon.de

ISSN 1864-7057

The JENA ECONOMIC RESEARCH PAPERS is a joint publication of the Friedrich Schiller University and the Max Planck Institute of Economics, Jena, Germany. For editorial correspondence please contact markus.pasche@uni-jena.de.

Impressum:

Friedrich Schiller University Jena
Carl-Zeiss-Str. 3
D-07743 Jena
www.uni-jena.de

Max Planck Institute of Economics
Kahlaische Str. 10
D-07745 Jena
www.econ.mpg.de

University Patenting in Germany before and after 2002: What Role Did the Professors' Privilege Play?

Sidonia von Ledebur (corresponding author)
Philipps University Marburg
Deutschhausstrasse 10
35032 Marburg (Germany)
Fax: +49-6421-2828950
E-mail: Sidonia.vonLedebur@staff.uni-marburg.de

Guido Buenstorf
Max Planck Institute of Economics
Kahlaische Strasse 10
07745 Jena (Germany)
Fax: +49-3641-686868
E-mail: buenstorf@econ.mpg.de

Martin Hummel
Friedrich Schiller University Jena
Carl-Zeiss-Strasse 3
07743 Jena (Germany)
E-mail: martin.hummel@uni-jena.de

August 2009

Abstract:
We examine ownership patterns of German university-invented patents before and after the abolition of the 'professors' privilege' in 2002 to explore how the legal change affected patenting activities. Our data show a shift from individually-owned and firm-owned patents to university-owned patents, which becomes increasingly strong over the years. Differences in the patent experience of inventors and universities further help explain the variance in ownership patterns. Both experienced and inexperienced inventors are affected by the legal change.

JEL Classifications: O33, O34, O38
Keywords: university patenting, technology transfer, professors' privilege, Germany.

1. Introduction

Throughout the industrialized world, the importance of public research for the innovation performance of countries and regions has been emphasized in the past decades. In addition to their teaching and research missions, universities have increasingly been recognized as providers of useful knowledge inputs into private-sector innovation processes (Jaffe, 1989; Salter and Martin, 2001). Based on this insight, there has been a widespread concern among policy makers that the potential of universities to support private-sector innovations is not fully exploited, and that the results of public research – which, after all, receives substantial support from tax payers – could and should be put to better societal use (European Commission, 2003; OECD, 2003; cf. also Dosi et al., 2006).

Time and again, these concerns have motivated policy changes targeting an improved transfer of knowledge and technologies from public research to the private sector. Policy makers have been particularly active with regard to intellectual property rights (IPRs) over university inventions. In the U.S., the Bayh-Dole Act of 1980 gave universities a blanket permission (and obligation) to seek IPR protection for technologies that their researchers develop in research funded by federal agencies. This new IPR regime replaced a complex network of bilateral agreements between individual sponsoring agencies and universities, which had been complemented by case-by-case arrangements (Mowery and Sampat, 2001). Following the Bayh-Dole Act, the numbers of patent applications out of U.S. universities soared. Some universities secured substantial amounts of income from licenses and patent sales.

There is strong empirical evidence suggesting that the increased patenting activities out of U.S. universities are at most partially due to the Bayh-Dole Act (Mowery et al., 2001). This evidence notwithstanding, the Bayh-Dole Act has been emulated by policy makers in other countries. Among these countries was Germany, where a Bayh-Dole-like IPR regime for university inventions was adopted in 2002. Specifically, lawmakers abolished a special clause in the law on employee inventions (*Arbeitnehmer-erfindungsgesetz,* cf. ArbEG, 2002) that had hitherto exempted university researchers from the general obligation of employees to disclose job-related inventions to their employers. This clause, which had allowed university researchers to retain the ownership in their inventions, was known as the professors' privilege (*Hochschullehrerprivileg*).

[insert Figure 1 about here]

Somewhat paradoxically, even though abolishing the professors' privilege was motivated by the apparent success of the Bayh-Dole Act, in effect the reform did not allocate the IPR in university inventions closer to the inventor, as Bayh-Dole had done, but rather removed them from the inventors to their employers (von Ledebur, 2008; cf. also figure 1). In contrast to the U.S., the German suspicion was not that university inventions might be shelved because IPR negotiations between university administrations and federal agencies were obstructed by red tape. Rather, German policy makers were concerned that individual researchers might be unwilling or unable to pursue the commercial application of their ideas through patenting and licensing activities. Dedicated technology transfer offices (TTOs) were seen as better suited to fulfill these tasks, and accordingly the change in the legal treatment of university inventions was complemented by substantial federal subsidies for newly established TTOs (Bielig and Haase, 2004).

There has been an extensive scholarly discussion on the effects of the Bayh-Dole Act (cf., e.g, Henderson et al., 1998; Mowery et al, 2001; Mowery and Ziedonis, 2002; Shane, 2004; Sampat, 2006). Empirical analysis of the German reform is nonetheless justified because it may not necessarily have had the same kinds of effects that were observed in the U.S.. We already noted how the German reform effectively differed from its U.S. counterpart. In addition, idiosyncratic elements of the German public research system and its IPR regime limit the extent to which the evidence on the U.S. as well as that on reforms in other European countries (most importantly, the pioneering work by Valentin and Jensen, 2007 and by Della Melva et al., 2008 who analyzed the effects of similar legal changes in Denmark respectively France) can be generalized to the German case. First, Germany has a unique division of labor between universities and non-university public research organizations (PROs). As the professors' privilege only covered university researchers, but not the employees of the non-university PROs, a hybrid IPR regime existed prior to the reform of 2002, which may have affected the effectiveness of the reform. Second, qualitative evidence shows that some universities had established a technology transfer infrastructure already before 2002, and that even though mandatory disclosure was inexistent, a substantial number of patents were owned by universities. Third, and related, before German reunification, socialist East Germany had not known a professors' privilege. Patenting activities had been part of the mission of East German universities, which were much less autonomous than their Western counterparts (cf. Albrecht, 2001, for an illustrative historical case study). As a consequence, patenting experience differed substantially among German professors.

These considerations suggest that studying the effects of the German reform of 2002 is important. Doing so is considerably complicated, however, by the limited access to the relevant data. Given the historical IPR regime, only a minority of university-invented patents were owned by the universities before 2002. Similar to other European countries, this necessitates a search for university inventors rather than university-owned patents (cf. Lissoni et al., 2007). At the same time, because of the decentralized character of the German educational and research institutions, identifying patent active university researchers by staff lists is hardly possible.

We adopt a two-stage approach to deal with this challenge. We initially analyze university patents identified through a variant of the method pioneered by Becher et al. (1996) and Abramson et al. (1997) which is based on the professor title of inventors in patent databases. To probe the robustness of the findings thus obtained, we then study the patenting behavior of the full population of professors in patent-relevant fields at six strategically selected German universities.

We find no evidence that the overall numbers of university-invented patents in Germany increased after 2002. This is consistent with the only other study that to our knowledge has addressed this issue before (Schmoch, 2007). The analysis of patent ownership finds that after the 2002 reform German researchers had a greater propensity to assign patents to their university than before. University ownership is not associated with higher patent quality. Our results moreover suggest that the new legislation may have disturbed existing university-industry links. Most importantly, after the reform we find a larger propensity for university ownership of patents not only for researchers who newly begin to patent, but also for experienced inventors with pre-reform patents.

The remainder of this paper is structured as follows. Drawing on theoretical considerations as well as prior empirical findings, in section 2 we develop a set of hypotheses on the expected effects of the abolition of the professors' privilege. Data and empirical methodology are discussed in section 3. In section 4 we present the results of analyzing the two datasets. A discussion of these results follows in section 5, before concluding remarks are made in section 6.

2. Incentives, Experience, and Patent Applications: Expected Effects of the 2002 Legal Reform

Effects of the 2002 reform on German university IPR may be reflected both in the total numbers of university-invented patents as well as in their ownership patterns. Ownership patterns of university-invented patents[1] are complex, reflecting differences in institutional setups as well as individual preferences and constraints. Based on the type of applicant (assignee in the U.S. terminology), patent applications based on inventions by university researchers can be divided into university-owned, firm-owned and individually-owned ones. University-invented patents may also have multiple applicants. For example, inventions based on collaborative research are frequently owned jointly by a university and a private-sector firm, or by a university and a non-university PRO.

Under the pre-2002 legal regime, university inventors could freely decide whether and through what channels to apply for patents. On the downside, many universities did not provide support to faculty inventors, which turned commercialization activities into the researchers' private business. However, the empirical record shows that not all universities were equally passive with regard to IPR-based technology transfer activities. A number of universities owned patents even before disclosure became mandatory in

1 University-invented patents are also referred to as academic patents (cf. e.g., Sapsalis and van Pottelsberghe, 2007). We will also use the term university patents synomynously.

2002. This indicates both that these universities were interested in technology transfer and that at least some of their professors were willing to commercialize inventions through the universities.

This willingness may reflect the uncertain and costly nature of patenting. On the one hand, university inventors who applied for patents in their own name had to bear the substantial efforts and costs of the application process. To make money, they moreover had to find buyers for their patents or licensees willing to commercialize their inventions. On the other hand, if commercialization was successful, faculty inventors retained all of the ensuing income. Thus, patenting was a risky but potentially quite profitable activity.

The reform of 2002 was enacted on the presumption that many researchers were deterred from technology transfer activities under the prevailing conditions. However, there was another, often more favorable alternative open to university inventors. In the pre-2002 years professors frequently did not apply for a patent in their own name, but the application was made by a private-sector firm, particularly if the invention was based on prior research collaboration. In these cases, the firm bore the financial risk of the application, with the remuneration of the university inventor being negotiated between both parties.

After 2002, university inventors faced substantially shifted financial incentives. With the university being the legal owner of their inventions, inventors no longer had to bear the financial burden of the patent application, but the law required universities to pay for all ensuing costs. The reduced financial risk should have lowered the threshold for professors to engage in patenting activities, which should have increased the total number of patent applications based on inventions made by university researchers. It is conceivable that this effect was further reinforced by enhanced technology transfer awareness and the newly established TTO infrastructure accompanying the 2002 reform.

While these considerations suggest that inventors who would previously have applied for a patent in their own name are better off after the reform, there are substantial reductions in the amount of income that successfully commercialized inventions now generate for their inventors. The law mandates that inventors receive 30% of the gross income the university generates from commercializing their inventions. This is considerably more than private-sector firms normally pay their employee inventors, but much less than the 100% (of net income) that inventors used to get before.[2] As a consequence, professors at the top end of the distribution of expected pay-offs face reduced expected incomes, which may reduce their willingness to engage in patenting.

The effects of the new legislation further differ for university inventors who collaborate with private-sector firms and used to assign their patents to the private-sector partner before 2002. In principle, this is still possible, provided the underlying invention was not made as part of the inventor's job, but was, e.g., the result of consulting activities (cf. Thursby et al., 2007). Also, private-sector ownership of a patent may be the outcome of negotiations between a firm and the university's TTO. In practice, however, the boundary between research and consulting will often be hard to draw, and the university may insist on its ownership of inventions made in research collaborations. As a consequence, some substitution of university ownership for firm ownership of patents can be expected. Furthermore, even the absolute numbers of patentable inventions might decrease, since the existence of a third party (the university) will complicate negotiations with private-sector firms as compared to the earlier situation when professors could freely decide how to commercialize their inventions. This increase in transaction costs might deter private-sector collaboration partners. In line with these considerations, prior work on the commercialization of Danish biotechnology patents has found adverse effects of the Danish Bayh-Dole-like reform (Valentin and Jensen, 2007).

With regard to the overall number of university-invented patents, it seems plausible to expect that the effective insurance provided by the new IPR regime against the risk of losing money from patent applications may induce enhanced patenting efforts by university researchers. This effect is expected to dominate potential negative effects stemming from the diminished payoffs for successfully commercialized inventions, as well as from frustrated negotiations with private-sector firms. In most cases, the respective inventions would still be expected to be patented, because the alternative for the inventor would be to forego all potential payoffs. Further adding to the expected

---

2 It is also below the U.S. average of about 40% (Lach and Schankerman, 2008).

increase in university-invented patents is that university administrators also faced stronger incentives to engage in patenting activities after the 2002 reform. Not only may successful commercialization result in substantial monetary rewards for the university, as has happened in some U.S. cases. As the new legislation requires universities to engage in technology transfer activities, compliance can be signaled by large numbers of patent applications. These considerations motivate the following hypothesis on the overall development in the number of applications for university-invented patents:

> Hypothesis 1: The total number of applications for university-invented patents (in relation to the overall development of patent applications in Germany) increased after 2002.

In addition to this effect on the number of university-invented patents, we also expect that the 2002 reform influenced the patterns of patent ownership. The reform clearly favored university-owned patents, which accordingly are predicted to have become relatively more frequent after the professors' privilege was abolished:

> Hypothesis 2a: The share of university-owned patents among all university-invented patents increased after 2002.

From a technology transfer perspective, it is particularly relevant what types of ownership are replaced by an increased share of university-owned patents. Based on the above considerations, we expect to find that individually filed patents are most strongly discouraged by the new legislation. They should only be observed in illegitimate cases of TTO circumvention or in cases where the university gave the invention back to the inventor after a negative assessment of its commercialization odds. The likelihood of the latter situation is reduced by the strong incentives for university administrations to signal their technology transfer activities through a large number of patent applications. We accordingly predict the following:

> Hypothesis 2b: Among all forms of patent ownership, the share of individually-owned patents decreased most strongly after 2002.

The share of firm-owned patents may also have been reduced by the 2002 reform. As was argued above, the additional uncertainty and transaction costs brought about by university-owned patents may deter private-sector firms from working with university researchers. In addition, universities may increasingly opt to retain the ownership in their researchers' inventions rather than selling them to commercial collaboration partners or licensees. Ownership patterns would then shift away from the private sector toward the university. Note that such a shift may be economically relevant. If private-sector agents have superior commercialization capabilities, the shift toward university ownership, and thus reduced private-sector control over patents, has adverse effects on technology transfer.

It is likewise conceivable that patents emerging from collaborations between universities and non-university PROs are increasingly applied for by the universities. Similar to collaborations with private-sector firms, both financial and reputation motives may lead universities to retain the ownership in these patents. Since German PROs such as the Fraunhofer and Max Planck Societies had well-established TTO infrastructures before 2002, this kind of shift may again have adverse effects on technology transfer.

Hypothesis 2c: The shares of firm-owned and PRO-owned patents also decreased after 2002.

Hypotheses 2a-c can be summarized as predicting that university ownership gained importance vis-à-vis all other forms of ownership after 2002. However, based on prior analyses, we expect that the extent and type of university-invented patents are not fully explained by the legal framework alone. In particular, prior work has found that a university's support infrastructure for technology transfer is an important determinant of its researchers' patenting and commercialization activities (cf. Friedman and Silberman, 2003, for an overview). Whether an individual researcher is willing to engage in patenting activities through the university's TTO and whether the university is able to successfully screen its professors' research for patentable output depends on the TTO's quality, age, and size. Well-functioning TTOs do not only require well-trained (and competitively paid) staff, but also close relationships to the private sector based on personal contacts, networks, and knowledge of potential licensees of university-owned patents. This needs time to evolve. Studying patenting activities of German universities, Huelsbeck and Menno (2007) find positive effects of the university's patent experience on the number of its subsequent patent applications. We similarly expect to find the share of university-owned patents to vary across universities according to the extent of the universities' patenting experience:

> Hypothesis 3: The more patenting experience a university has, the larger is the share of patents based on its researchers' inventions that are assigned to it.

Experience is also relevant on the individual level. Some professors began to engage in patent activities 30 years ago, when there was virtually no technology transfer infrastructure at (West) German universities. These researchers could in general only file patents in their own name or through private-sector collaborations. In doing so, they presumably acquired skills and experience that also shape their later patenting activities. We therefore expect more experienced patentees to be less likely to have university-owned patents than less experienced ones:

> Hypothesis 4a: The later inventors started to patent, the more likely they assign patents to the university.

Finally, not only overall ownership patterns may differ according to inventor experience, but also the effect of the 2002 reform. Specifically, we expect to find that the elimination of the professors' privilege most strongly affected patent-inexperienced researchers in assigning patents to their university:

> Hypothesis 4b: The 2002 reform had stronger effects on researchers who had no prior patent applications.

Distinguishing effects on new versus experienced inventors is relevant for an overall assessment of the 2002 reform. An extreme form of Hypothesis 4b would posit that only new inventors were affected by the new legal framework, whereas experienced inventors continued their patenting activities much like before. If this were supported by the empirical evidence, a negative overall effect of the reform would seem much less likely than if we found pervasive effects on experienced inventors, in particular those with established private-sector links leading to firm-owned patents. We will pursue these issues in the subsequent empirical analysis.

3. Data and variables

3.1 Datasets

University-invented but not university-owned patents are notoriously difficult to identify in patent databases. For several European countries (but not Germany), the *KEINS* project solved the problem by collecting and analyzing governmental listings of university researchers (cf. Lissoni et al. 2007). Adopting the same approach for Germany would be complicated by two institutional factors. First, the German university system is highly decentralized, with the federal *Länder* being in charge of educational issues. As a consequence, staff lists would have to be obtained from 16 individual regional governments rather than the Federal government. Second, privacy and staff representation issues are taken very seriously in Germany, further reducing the likelihood that official staff lists could be obtained.

Faced with these challenges, we based our primary identification strategy on the fact that in Germany academic titles are treated as a part of individuals' names. German professors frequently use their title in patent applications, which has been exploited for empirical research into German university inventions ever since the pioneering work of Becher et al. (1996). Following these authors, our initial step was to search for patent applications made by German universities (including *Fachhochschulen*) that had the text "prof" in the inventor field. The search was done in DEPATISnet, the online patent database of the German Patent Office (DPMA).

Identifying university inventors by professor titles is not without limitations. First, researchers below the professor rank are excluded. Second, titles may not be used consistently in patent applications. And third, many top-level R&D employees of German firms, in particular large and R&D-intensive ones, hold honorary professorships at German universities. The same holds for top-level researchers of non-university PROs such as the Fraunhofer and Max Planck Societies. Both groups of individuals were not affected by the 2002 reform and should thus not be included in our analysis.

To minimize the false inclusion of non-university inventors, we deliberately chose to limit our initial searches to university-owned patent applications. Based on extensive web searches for the about 1,300 professors who had originally been identified as inventors of university patents, we excluded individuals who were not full-time university employees or retired before 2004. We also searched for the inventors' gender, year of PhD completion, year of first patent application, current university affiliation, and the year of the respective university's first patent application. Homonyms were checked for on the basis of comparing residences, assignees, and technology classes of patents. This was facilitated by the fact that there are relatively few homonyms in German-speaking countries, and our dataset includes only a small number of individuals with widespread names.

For the remaining 986 professors, a manual search of all their patent applications with German or European priority in the period 1991-2006 was then conducted (irrespective of whether or not the professor title was used in the individual application). The owners of these patents were classified into 7 groups: (1) German universities (if applicable: jointly with individuals); (2) non-profit organizations other than German universities; (3) joint applications of universities and firms; (4) firms; (5) individuals; (6) joint applications of universities and non-profit research organizations; and (7) firms that employed the (future) professor at the time of the patent application. Group 7 is of no interest for our analysis because these patents are not university-invented. They are relevant, however, when searching for the year an inventor first engaged in patenting.

Group 2 is made up from two different subgroups. It includes non-university PROs, but also a number of private entities with names such as "friends and sponsors of technology transfer of chair X at university Y". These entities reflect pre-reform efforts by individuals and sponsoring firms to establish transfer intermediaries. Their patent applications are limited to the pre-2002 years, which may account for some reduction in the share of this ownership group following the legal reform.

Our dataset is an order of magnitude smaller than that used by Schmoch (2007) in a similar context. This is primarily because our identification strategy excludes inventors who never had university-owned patents. Before addressing this issue, we discuss two further factors accounting for the smaller size of our sample. In both cases, the affected patents are not university-invented and therefore rightly excluded from the analysis.

As regards firm-owned patents, we suspected that honorary professors who are full-time employees of private-sector firms might be one factor accounting for our smaller sample size. To see whether this was a relevant concern, we conducted DEPATISnet searches for professors appearing on the patent applications of the seven most patent-active German companies (Siemens, Bosch, BASF, Bosch-Siemens-Hausgeräte, Bayer, Daimler, Infineon; overall a sample of 161 individuals). The results indicated that employees holding honorary professorships account for about 50% of all patents owned by the respective firms that have a professor among their inventors. Retired professors and those working at foreign universities or non-university public research institutes each account for another 10% of the patents.

In contrast to these highly productive inventors of firm-owned patents, differences in the samples of individually-owned patents are mostly caused by occasional inventors. Many inventors in this group only have one or two patent applications. To learn more about them, we drew a random sample of 100 individuals with own patents and a professor title. Analyzing this sample suggests that 70% of all patents do not fall into categories relevant for our analysis. The respective inventors are mostly medical professors working at non-university hospitals, firm owners, or individuals for whom we were unable to obtain any information on the web, which suggests they are not active university researchers. We therefore conclude that our data on individually-owned patents largely cover the relevant population of university-invented patent applications.

The remaining difference between our dataset and the full population of university-invented patents according to Schmoch (2007) is due to academic inventors who never had a patent owned by a university or who did not use their professor title on any university patent application. Accounting for the first group is important in interpreting the findings of our analysis. Some conjectures about the effect of the legal reform on them appear straightforward. On the one hand, that they have no university-owned patents after 2002 shows that they did not benefit from the "insurance" provided by the reform. On the other hand, we see no good reason why the reform should have enhanced their ability and willingness to apply for non-university-owned patents. If anything, we expect that after the reform assigning patents to private-sector firms became more difficult because it may lead to conflicts with the employing university. These considerations suggest that inventors who never had university-owned patents at best did not benefit from the 2002, and may even be affected negatively. We thus conclude that our results are biased in favor of the reform, as potential negative effects on the transfer activities of the missing individuals are not captured in the analysis.

[insert Table 1 about here]

To check the robustness of the results obtained on the basis of the nationwide dataset, we constructed a second dataset using a different empirical strategy. For six strategically selected universities (Darmstadt, Dresden, Jena, Marburg, Stuttgart, and Tübingen; cf. Table 1), the full population of professors in patent-relevant fields (sciences, engineering, medical and pharmaceutical sciences) was identified on the basis of course and staff directories for the 2001/02 winter term. These universities represent three regions (Hesse, Baden-Württemberg, and Eastern Germany) with different traditions of technology transfer activities before 2002. For the two universities in Hesse, no university-owned patent applications are documented prior to 2002. In contrast, the Eastern universities started to apply for patents before German reunification. In Baden-Württemberg institutionalized transfer activities including university-owned patents were taken up in the 1990s. For each of the regions, we selected both a university of technology (*Technische Universität*) and a traditional full university.[3] For all professors thus identified we then searched their patents and additional information. Again, all individuals who are no full-time university employees (i.e. honorary and extraordinary professors) were excluded, which resulted in a sample of 398 individuals with patent applications.

3 Even though officially a full university since 1967, the University of Stuttgart (former *Technische Hochschule*) still has the profile of a university of technology. The Dresden University of Technology has a medical school, but the main focus of the university is on technology.

3.2 Descriptive statistics

The national dataset contains a total of 5,624 patents. The average number of patents per professor is 6.21 (the median is 4). 453 patents had more than one of our 986 professors among their inventors. For the analysis, we always use the individual and university data of the oldest professor (earliest year of PhD), based on the assumption that the most senior researcher had the greatest influence on what happened with the patent. German priority dominates with 5,195 patents (92%). Among these, 1,533 patents had additional publication documents with a European number, thus there are a total of 1,962 European patents, and the average patent active professor in the dataset has 2 European patent applications. Figure 2 and Table 2 show that firm-owned patents dominate among the non-university-owned patents.[4] Yearly patent applications in our dataset have a positive trend over the whole period – with a temporary decline from 2002 to 2004.[5]

[insert Table 2 and Figure 2 about here]

Tables 3 and 4 list the explanatory and control variables used in the empirical analysis, as well as the corresponding descriptive statistics. There are two alternative measures for controlling the field of research: the IPC section of the patent application, and the researcher's department. In case of interdisciplinary departments we identified the field of a researcher's PhD in the dataset of the German National Library, where all PhD theses in Germany are recorded, including the year of the PhD.

[insert Tables 3 and 4 about here]

The key explanatory variables are the legal reform of 2002, which is measured by a dummy variable indicating patents filed after the reform (*law*), as well as the patent experience of individual inventors and the universities employing them. To measure individual experience, inventors are divided into three cohorts based on the years of their

4 There are 111 firm-owned patents of 22 (subsequent) professors who were at that time employed at the respective firm (group 7). These patents are excluded in the following. 64 patents with combinations of (2)+(4) and (1)+(2)+(4) were excluded to keep the number of categories manageable. Merging these patents with one of the other groups would have required assumptions that could bias our results if incorrect. For simplicity, patents owned by non-university non-profit institutions are labelled "non-profit" in the following in order to summarize public and private research institutions.

5 The slightly lower number for 2006 compared to 2005 can be explained by delayed publication of patent documents.

first patents (before 1991, 1991-2001, and after 2001), which are each represented by a dummy variable (*patexpcoh1, patexpcoh2,* and *patexpcoh3*), while we take the year of the first patent application from the university to explain institutional experience (*unifirstpat*).[6] Prior studies suggest that there is no unique measure of patent quality (Harhoff et al., 2003; Lanjouw and Schankerman, 2004). Accordingly, to proxy for patent quality, we use a dummy variable indicating direct application at the European Patent Office (*epo*), as well as the size of the patent family (*famsize*) and the number of IPC classes (*numipc*). Further explanatory and control variables are described in Table 3.

In the dataset for the six selected universities there are 1,931 patents invented by 398 professors. *Privatdozenten* (lecturers) are included only if they subsequently obtained a professorship. On average, there are 5.15 patents per professor (some patents have more than one professor as inventors). Of the individuals in the dataset, 161 (or 38%) overlap with those of the main dataset. On the patent level, this corresponds to an overlap of 61% (1,174 patents). As was expected given the way the national dataset was constructed, we find a higher proportion of firm-owned patents here compared to the earlier dataset: they account for 46%, while universities are responsible for 25%, other research institutions for 11%, and 14% of the patents were filed by individuals. Joint ownership of the university and a firm or research institute each accounts for only 2% of the cases (detailed data in Table 5).

In contrast to the national dataset, we find a clear peak of patent applications in 1999 (Figure 3). This trend is the same as in Schmoch (2007). Again, there is an increase in university-owned patents after the reform, while numbers and shares of firm-owned and individually-owned patents strongly decreased (Table 5).

[insert Figure 3 and Table 5 about here]

6 The rationale for the different approach towards individual and institutional experience is that for most inventors we have the first patent among our data. This is less often the case for universities because the first patent application frequently comes from an inventor not included in our dataset.

4. Results: Patent Applications by German Professors, 1991-2006

4.1 National dataset

We begin by examining whether the absolute numbers of university-invented patents systematically increased after 2002. To reflect the increasing trend in overall patent applications, the development of applications based on university inventions is compared to the overall pattern in patent applications at the DPMA. Figure 4 (left panel) shows that the share of university-invented patents among German patent applications increased during most of the time period observed. However, visual inspection does not suggest this trend became further pronounced after the reform. This impression is confirmed by a Chow test that likewise does not suggest a structural break in 2002. Accordingly, there is no robust evidence in favor of Hypothesis 1. There is, however, a steep increase in the share of university-owned patents among all university-invented patents in our dataset. In Figure 4 (right panel) we can see how this share increased from 2002 onwards, after it had been stagnating for several years.

[insert Figure 4 about here]

In order to test the remaining hypotheses, we use multinomial logit models estimating the likelihood of a patent to be assigned to the alternative categories of ownership in comparison to the base category of university ownership (cf. Thursby et al., 2007; Della Melva et al., 2008). Due to the relatively small number (83) of patents jointly owned by a university and a non-profit organization (group 6), we drop these patents from the analysis.[7] Results for this specification are reported as Model 1 in Table 6.[8] In this and all following models, standard errors have been adjusted for multiple patents per inventor.

[insert Table 6 about here]

7 As a robustness check, we alternatively included these patents in the category (2) of applications by non-profits. This did not have appreciable effects on the results (which are available from the authors).

8 Full information is available for only 5,151 patents, but when excluding variables with missing information (mainly *phdyear*) the coefficient estimates of the other variables hardly change. We use departmental affiliations rather than IPC sections to measure fields of research because they have more explanatory power.

The primary result is the effect of the abolition of the professors' privilege on patent ownership. We find that, in line with Hypothesis 2a, patents filed after 2002 are much more likely to be university-owned, as the likelihood of all other forms of ownership decreases.[9] This result is in line with the findings of Della Malva et al. (2008) who analyze the effect of similar changes on university patenting in France. Combined with the apparently small changes in the total number of university-invented patents after 2002, it seems that the reform primarily affected the ownership of patents. The results moreover suggest that the reform had the strongest displacement effect on individually filed patents, which supports Hypothesis 2b. In line with Hypothesis 2c, the likelihood of assignment to firms and non-profit organizations also decreased significantly.

It is conceivable that these changes in patent ownership reflect short-term effects limited to the first year(s) after the law was enacted. To test for this possibility, in Model A1 (see appendix) we subdivided the *law* variable into yearly dummies (*law2002-law2006*). Contrary to the conjecture of short-term effects, this reveals an increasingly stronger trend toward university ownership: the coefficients of *law2006* are twice as large in absolute terms as those of *law2002* for categories 4 and 5.

The other key explanatory variables show strong influences as well. As regards the role of dedicated patent policies and successful commercialization activities at the university level, the positive influence of *unifirstpat* on all groups (significant for individually and firm-owned patents) shows that professors employed at universities with longer experience in patent activities (smaller value of *unifirstpat*) are more likely to have university-owned patents. Thus, Hypothesis 3 is supported. Furthermore, the later individual researchers started their patenting activities, the more probable it is that their patents are assigned to universities compared to all other groups (except for group 3, for which *patexpcoh2* and *patexpcoh3* are insignificant). Thus, Hypothesis 4a is supported.

The number of inventors, *invcount*, is significant in all categories: individually-owned patents on average have fewer inventors than university-owned ones. In contrast,

9 To assess the magnitude of this effect, we lumped all alternative ownerships and estimated a logistic regression analogous to Model 1 with university ownership as the dependent variable. The coefficient estimate obtained for *law* in this model implies that patents filed after the reform were almost five times as likely to be owned by a university as pre-reform patents.

firm-owned patents (whether jointly with a university or not) as well as non-profit-owned ones have more inventors. These forms of ownership often reflect collaborations of universities with firms or research institutions. The variable *multprofs* also implies collaboration (but with a different type of researcher), and the two variables correlate only moderately. Having more professors from our dataset as inventors increases the probability of university ownership in comparison to all other categories.

To test whether the effects of the legal reform vary between professors with different patent experience (Hypothesis 4b), new interaction variables are introduced and a new model (Model 2 in Table 7) is estimated. As the critical issue is whether or not individuals had patenting experience under the professors' privilege, the two cohorts with the longest experience (*patexpcoh1* and *patexpcoh2*) are merged, and the effect of *law* is estimated separately for *lawexpcoh12=law * (patexpcoh1 + patexpcoh2)*, i.e. a dummy for all patents after 2002 from experienced professors, and *lawexpcoh3*, a dummy for the patents of those researchers with first patent experience after the legal reform. *Lawexpcoh3* is identical with *patexpcoh3*, because by definition the respective individuals do not have patent experience prior to 2002.

[insert Table 7 about here]

The results from estimating Model 2 indicate that both newly patenting researchers and those with prior experience have been affected by the legal reform: the probability of university ownership increases for both groups. However, the effect of the law is roughly twice as large for researchers without patent experience under the old law (differences in coefficient estimates are significant at the 0.01 level for all ownership categories except category 3). Thus, Hypothesis 4b is supported.

The proxy variables for patent quality included in Models 1 and 2 indicate that firm-owned patents on average were of higher quality than university-owned ones, which may reflect better underlying technologies and/or better IPR management. If firm-owned patents are inherently superior, then the trend toward university ownership may have adverse effects on patent quality. However, the quality of university-owned patents may have improved sufficiently after the 2002 reform to match that of firm-owned patents.

To test this possibility, we estimated another model, interacting the quality measures with the *law* variable (Model A2 in the appendix). The results show that the probability of firm-owned patents to be filed at the EPO is still higher than that of university-owned patents after the reform, even though the difference is reduced substantially. Larger patent families are even more often associated with firm ownership after 2002. In terms of patent scope, firm-owned patents filed after the reform are indistinguishable from university-owned ones. These findings suggest that the quality differential between firm-owned and university-owned patents has persisted after 2002.

4.2 Patent Applications by Faculty of Six Selected Universities

The above findings suggest that the 2002 reform had pronounced effects on the ownership patterns of university-invented patents in Germany. However, it cannot be ruled out that some of the findings are influenced by the limitations of the dataset, in particular the exclusion of professors without university-owned patents before or after the reform. To address this concern, we replicated the analysis using the dataset covering the population of professors at six selected universities (see section 3.1 above).

Again we begin by examining the absolute numbers of patent applications before and after the professors' privilege was abolished. Figure 3 shows that the maximum number of 186 applications in 1999 was not reached again in any of the post-reform years. Furthermore, the negative trend observable after 1999 could not be stopped by the change in legislation. Accordingly, Hypothesis 1 can be rejected clearly.

Next, we turn to the ownership patterns of patents on inventions from the six selected universities. We employ the same approach as for the national dataset. However, since the dataset is smaller, ownership group 3 does not contain enough patents (35) to lead to reliable results, and is therefore excluded from the analysis.[10] The regression yields very similar results to those obtained for the national dataset (cf. Table 8). Our key

10 Most importantly, there are no patents in this category whose inventors have no pre-reform patent experience. Some of the control variables are also not identified for this group. Experimental model specifications that included ownership group 3 yielded very similar results to those reported below.

explanatory variable, *law*, is of similar magnitude as in Model 1 and significant in all categories.

[insert Table 8 about here]

Instead of *unifirstpat*, Model 3 (and likewise Model 4 below) includes dummy variables for the individual universities. The coefficient estimates for these variables indicate that at the two East German universities (Jena and Dresden) university ownership is more likely than in the West. This result is consistent with our expectations given the different traditions of institutionalized technology transfer efforts at the various universities, and also with the results obtained for *unifirstpat* in Models 1 and 2.

As before, we also examine the effect of the legal reform separately for professors of differing patent experience. Analogously to Model 2, Model 4 (Table 9) displays the probabilities of the various forms of ownership for professors who filed their first patent prior to 2002 (*lawexpcoh12*) and those who filed their first patent afterwards (*lawexpcoh3*). The differences between the two groups are smaller than those found for the national dataset and statistically insignificant, but the coefficient estimates are suggestive of a stronger effect on professors without patent experience prior to 2002.

[insert Table 9 about here]

5. Discussion

After the professors' privilege was abolished in the German law on employee inventions in 2002, the frequency of university-invented patents has not increased. Depending on which dataset we look at, we find that the number of patents has stagnated or even decreased after 2000. The policy objective of having more academic patents has been missed. As expected, the number of university-*owned* patents has increased sharply in both datasets, accompanied by an absolute and relative decrease of patents filed by their inventors individually or in the name of firms and research institutes.

Our results therefore indicate that the law primarily affected assignment patterns, and not necessarily for the better. The reduced likelihood of patents to be filed in the inventor's own name may be a welcome development, particularly with respect to inexperienced inventors. From the inventor's view, those researchers who lacked institutional support in the past now have access to an improved transfer infrastructure. From a technology transfer perspective, the probability of successful commercialization might be higher for university ownership due to more patenting experience, more diverse industry contacts and more time investment of TTO staff.

However, firm-owned patents have also been displaced by university-owned patents after 2002. This development has affected both novices and experienced inventors, which indicates that established science-industry links have been disturbed by the new legislation. University ownership of patents means that firms willing to commercialize university inventions face higher transaction costs. Broader use of the technology in the private sector could only be ensured if licenses on university technologies were non-exclusive, which may further deter commercialization efforts.

In addition, anticipating problems in securing exclusive access to potentially profitable outcomes, firms may refrain from engaging in collaborative research activities with universities. Reductions in collaborative research may have further adverse effects on technology transfer, as the commercial application of inventions may be easier when firm researchers have been involved from the beginning and possess more in-depth knowledge about the technology to be commercialized. In line with these considerations, Crespi et al. (2006) present evidence that firm commercialize inventions more efficiently than universities, which is consistent with our finding that firm-owned patents tend to be of higher quality.

As discussed above, professors who have never filed a patent in the university's name are missing from our national dataset. We may therefore have a disproportionately large share of individuals in our dataset who benefit from the new law or have a favorable subjective opinion of it. This suggests that the results for the national dataset provide an upper bound estimate for positive effects of the legal reform, which may partly explain why in this dataset the overall number of university-invented patents does not decrease after 2002.[11] In contrast, the analysis of the six selected universities supports the findings of Schmoch (2007), showing a negative trend in university patenting after 1999 (cf. Figure 3). However, regarding the ownership patterns, the dataset of the six universities supports the results of the national dataset.

6. Conclusions

The present paper analyzed the effects of the abolition of the professors' privilege in Germany in 2002. We found no evidence of systematic increases in the numbers of university-invented patents after 2002. This is a first indication that the new legislation has not reached its objectives. The legal reform moreover produced a shift towards university ownership of patents, which displaced both individually-owned and firm-owned patents. Accordingly, patent ownership shifted away from private-sector innovators. We suspect that this shift may have adverse effects on the effectiveness of technology transfer, which is consistent with our finding that firm-owned patents seem to be of higher quality. The above analysis thus provides first hints that the legal reform in Germany has not facilitated technology transfer, but may even have created new obstacles to the effective commercialization of university technologies.

The empirical analysis identified various factors explaining the ownership patterns of university-invented patents. In addition to the legal framework, the likelihood of university ownership increased with the university's patenting experience. This suggests that transfer activities are influenced by the past practices and experiences at the individual university. We also found that patent ownership varies across fields of research.

From these findings, a basic question arises: is there a rationale for mandatory disclosure of inventions made by university researchers? There are substantial numbers

11 An additional factor is that we excluded all individuals who retired until two years after the legal reform, while young scientists with patent activities were included in the analysis if they assumed professorships prior to 2000 (and in individual cases even later).

of university-owned patents even before the professors' privilege was abolished, which shows that some professors sought university support in commercialization and were willing to assign their patents to the university even then. We also found that the experience of universities with patent activities enhances the probability of university ownership. This suggests that if policy makers are concerned about researchers who are unwilling or unable to commercialize their inventions on their own, setting up a support infrastructure for inventors and allowing for university-owned patents may be helpful to lower patenting barriers for these researchers. In contrast to the system of mandatory disclosure introduced in 2002, such a voluntary regime could at the same time ensure that existing connections to industry are not affected. Effectively, a competitive system would be installed that allowed all inventors to choose the type of patent ownership best suitable to their needs. A drawback of such a regime would be that universities are likely to end up owning the less attractive patents as well as those of less committed and experienced inventors. However, such problems of adverse selection may be limited provided that universities can still refuse to patent technologies that they evaluate as not sufficiently promising. To be sure, from a budgetary perspective a voluntary system is less attractive than mandatory disclosure. Yet the hope for revenues from commercialization as a new source of funding for universities could be misguided anyway: patent earnings are highly skewed and the experience shows that most technology transfer offices in the U.S. and Great Britain run at loss (Geuna and Nesta, 2006; Heher, 2006; cf. also von Ledebur, 2008).

References

Abramson, Norman; Encarnacao, Jose; Reid, Proctor P.; and Schmoch, Ulrich, 1997, *Technologietransfer-Systeme in den USA und Deutschland*, Karlsruhe / Washington D.C.: Fraunhofer IRB Verlag.

Albrecht, Helmuth, 2001, "Die Innovation des Lasers in Deutschland – Forschungen an der TU Berlin und der Universität Jena im Vergleich", In: Abele, Johannes; Berkleit, Gerhard; and Hänseroth, Thomas (eds.): *Innovationskulturen und Fortschrittserwartungen im geteilten Deutschland*, Cologne: Böhlau, 263-276.

ArbEG (Employee Invention Act) 2002, Gesetz zur Änderung des Arbeitnehmer-erfindungsgesetzes. Berlin: Bundesgesetzblatt - Bundesministerium der Justiz, January 24th 2002.

Becher, Gerhard; Gering, Thomas; Lang, Oliver; and Schmoch, Ulrich, 1996, *Patent-wesen an Hochschulen,* Bonn: Bundesministerium für Bildung, Wissenschaft, Forschung und Technologie.

Bielig, Andreas and Haase, Heiko, 2004, "Patente aus Hochschulen: Die Intellectual Property Rights-Frage", *Zeitschrift für Wirtschaftspolitik*, 53(2), 228-251.

Crespi, Gustavo; Geuna, Aldo; and Verspagen, Bart, 2006, "University IPRs and Knowledge Transfer. Is the IPR ownership model more efficient?", *SPRU Electronic Working Paper Series* no. 154.

Della Malva, Antonia; Lissoni, Francesco; and Llerena, Patrick, 2008, "Institutional change and academic patenting: French universities and the Innovation Act of 1999", University of Strasbourg: *Working Papers of BETA*, no. 2008-09.

Dosi, Giovanni; Llerena, Patrick; and Sylos Labini, Mauro, 2006, "The relationships between science, technologies and their industrial exploitation: An illustration through the myths and realities of the so-called 'European Paradox'", *Research Policy*, 35, 1450-1464.

DPMA(1998-2006): Jahresberichte.

European Commission, 2003, *Third European Report on Science & Technology Indicators: Towards a Knowledge-Based Economy*, Brussels.

Friedman, Joseph and Silberman, Jonathan, 2003, "University Technology Transfer: Do Incentives, Management, And Location Matter?", *Journal of Technology Transfer*, 28(1), 17-30.

Geuna, Aldo and Nesta, Lionel J., 2006. "University patenting and its effects on academic research: The emerging European evidence." *Research Policy*, 35, 790-807.

Harhoff, Dietmar; Scherer Frederic M.; and Voper, Katrin, 2003. "Citations, family size, opposition and the value of patent rights", *Research Policy*, 32, 1343-1363.

Heher, Anthony D., 2006, "Return on Investment in Innovation: Implications for Institutions and National Agencies", *Journal of Technology Transfer*, 31(4), 403-414.

Henderson, Rebecca; Jaffe, Adam B.; and Trajtenberg, Manuel, 1998, “Universities as a Source of Commercial Technology: A Detailed Analysis of University Patenting, 1965-1988”. *Review of Economics and Statistics*, 80(1), 119-127.

Huelsbeck, Marcel and Menno, Dominik, 2007, “German University Patenting and Licensing: Does Policy Matter?” Paper for the 2nd Annual Conference of the EPIP Association 2007.

Jaffe, Adam B., 1989, “Real effects of academic research”, *American Economic Review*, 79, 957-970.

Lach, Saul and Schankerman, Mark, 2008, “Incentives and invention in universities”, *RAND Journal of Economics*, 39(2), 403-433.

Lanjouw, Jean O. and Schankerman, Mark, 2004, “Patent Quality and Research Productivity: Measuring Innovation with Multiple Indicators”, *The Economic Journal*, 114(495), 441-465.

Lissoni, Francesco; Llerena, Patrick; McKelvey, Maureen; and Sanditov, Bulat, 2007, “Academic Patenting in Europe: New Evidence from the KEINS database”, Bocconi University: Cespri Working Paper no. 202.

Mowery, David C., Nelson, Richard, Sampat, Bhaven and Ziedonis, Arvids, 2001, “The growth of patenting and licensing by U.S. universities: an assessment of the effects of the Bayh-Dole-Act of 1980”, *Research Policy*, 30(1), 99-119.

Mowery, David C. and Sampat, Bhaven N., 2001, “University Patents and Patent Policy Debates in the USA, 1925-1980”, *Industrial and Corporate Change*, 10(3), 781-814.

Mowery, David C. and Ziedonis, Arvids A., 2002, “Academic patent quality and quantity before and after the Bayh-Dole act in the United States”, *Research Policy*, 31, 399-418.

OECD, 2003, *Turning Science into Business: Patenting and Licensing at Public Research Organisations*, Paris.

Salter, Ammon J. and Martin, Ben R., 2001, “The economic benefits of publicly funded basic research: a critical review,” *Research Policy*, 30, 509-532.

Sampat, Bhaven N., 2006, “Patenting and US academic research in the 20th century: The world before and after Bayh-Dole”, *Research Policy*, 35, 772-789.

Sapsalis, Elefthérios and van Pottelsberghe, Bruno 2007, “The institutional sources of knowledge and the value of academic patents”, *Economics of Innovation and New Technology*, 16(2), 139-157.

Schmoch, Ulrich, 2007, “Patentanmeldungen aus deutschen Hochschulen”, *Studien zum deutschen Innovationssystem* no. 10-2007.

Shane, Scott, 2004, “Encouraging university entrepreneurship? The effect of the Bayh-Dole Act on university patenting in the United States”, *Journal of Business Venturing*, 19(1), 127-151.

Thursby, Jerry, Fuller, Anne and Thursby, Marie, 2007, “US Faculty Patenting: Inside and Outside the University”, *NBER Working Paper* no. 13256.

Valentin, Finn and Jensen, Rasmus, 2007, “Effects on academia-industry collaboration of extending university property rights”, *The Journal of Technology Transfer*, 32(3), 251-276.

Von Ledebur, Sidonia, 2008, “Technology transfer offices and university patenting – a review”, *Jena Economic Research Papers*, no. 2008-033.

Tables and Figures

	Hesse (no patent activities prior to 2002)	Baden-Württemberg (focus on university patents started in the 1990s)	East Germany (long tradition of university patenting)
University with technological focus	Darmstadt	Stuttgart	Dresden
Full university with medical school	Marburg	Tübingen	Jena

Table 1: Overview of the selected universities in the second dataset.

Group No.	Applicant	Before 2002	2002 and later	Sum
1	University	547 (17%)	1156 (50%)	1703 (30%)
2	Other non-profit	317 (10%)	124 (5%)	441 (8%)
3	University and firm	45 (1%)	102 (4%)	147 (3%)
4	Firm	1391 (42%)	660 (29%)	2051 (36%)
5	Individual	856 (26%)	168 (7%)	1024 (18%)
6	Univ. and non-profit	29 (1%)	54 (2%)	83 (1%)
7	Former employer	128 (4%)	47 (2%)	175 (3%)
Total		3313	2311	5624

Table 2: Shares and absolute numbers of patents in the ownership groups (national dataset).

Key explanatory variables		Frequency of dummy variables = 1
law	dummy taking the value one if the patent was filed after the enactment of the new employee inventions act	2311/609
unifirstpat	year of the first patent application made by the employing university	
patexpcoh1	dummy taking the value one if the inventor filed his first patent before 1991	3128/1165
patexpcoh2	dummy taking the value one if the inventor filed his first patent between 1991 and 2001	2167/676
patexpcoh3	dummy taking the value one if the inventor filed his first patent after 2001	329/90
Further explanatory variables		
epo	dummy taking the value one for patents with European priority	429/147
famsize	number of patent documents with different country codes	
numipc	the number of different IPC classes	
invcount	number of inventors	
multprofs	dummy taking the value one if there is more than one professor of our dataset among the inventors	453/113
phdyear	year of the PhD of the professor	
phdabroad	dummy taking the value one if the PhD is from a non-German university	235/-
Control variables		
female	dummy taking the value one if the inventor is female	85/27
techuni	dummy taking the value one for universities with technical specialization	1854/1072
uni	dummy taking the value one for research universities that are no technical universities	3222/859
fh	dummy taking the value one for universities of applied sciences (Fachhochschulen)	515/-
othcat	dummy taking the value one for all other employers, e.g. non-university hospitals	33/-
A – H	IPC section dummies	
me	dummy taking the value one for professors in mechanical engineering	1410/510
ee	dummy taking the value one for professors in electrical engineering	702/97
chem	dummy taking the value one for professors in chemistry	1190/398
phys	dummy taking the value one for professors in physics	544/114
lifesci	dummy taking the value one for professors in biology as well as the medical and pharmaceutical sciences	1397/669
it	dummy taking the value one for professors in IT and mathematics	164/80
othfield	dummy taking the value one for professors in any other subject	193/84

Table 3: List of variables (dummy freq.: national dataset / six selected universities).

variable	obs	mean	s.d.	min	max
famsize	5624	1.83	3.22	0	32
invcount	5624	3.50	1.91	1	15
phdyear	5410	1979	8.63	1955	2003
numipc	5624	3.98	3.90	1	67
unifirstpat	5592	1984	15.0	1957	2006

Table 4: Summary statistics of integer variables (national dataset).

Group No.	Applicant	Before 2002	2002 and later	Sum
1	University	266 (18%)	211 (46%)	477 (25%)
2	Other non-profit	178 (12%)	29 (6%)	207 (11%)
3	University and firm	26 (2%)	9 (2%)	35 (2%)
4	Firm	707 (48%)	178 (39%)	885 (46%)
5	Individual	260 (18%)	16 (3%)	276 (14%)
6	Univ. and non-profit	25 (2%)	13 (3%)	38 (2%)
7	Former employer	10 (1%)	3 (1%)	13 (1%)
Total		1472	459	1931

Table 5: Shares of ownership groups (selected universities).

Model 1	non-profit (2)			uni+firms (3)			firms (4)			individuals (5)		
variables	coeff.		std.err.	coeff.		std.err.	coeff.		std.err.	coeff.		std.err.
law	-1.602	***	(0.235)	-0.049		(0.328)	-1.305	***	(0.138)	-2.262	***	(0.163)
unifirstpat	0.006		(0.010)	0.008		(0.012)	0.017	***	(0.006)	0.040	***	(0.008)
patexpcoh2	-0.449	*	(0.240)	0.264		(0.400)	-0.547	***	(0.187)	-0.374	**	(0.189)
patexpcoh3	-2.170	***	(0.569)	-0.564		(0.489)	-1.815	***	(0.296)	-2.005	***	(0.413)
epo	1.399	***	(0.345)	0.607		(0.507)	1.645	***	(0.247)	0.358		(0.306)
famsize	0.145	***	(0.039)	0.056		(0.065)	0.206	***	(0.030)	0.030		(0.039)
numipc	0.008		(0.024)	-0.007		(0.030)	0.039	**	(0.016)	0.021		(0.018)
fh	-0.109		(0.427)	-0.400		(0.484)	-0.557	**	(0.273)	-0.282		(0.318)
techuni	-0.197		(0.307)	-0.612	*	(0.341)	-0.165		(0.197)	0.211		(0.224)
phdyear	0.023		(0.015)	0.013		(0.019)	0.029	***	(0.009)	0.000		(0.011)
phdabroad	-1.451	***	(0.480)	0.459		(0.540)	0.031		(0.394)	-1.279	**	(0.537)
multprofs	-1.765	***	(0.348)	-1.370	***	(0.507)	-1.791	***	(0.207)	-0.579	**	(0.248)
invcount	0.387	***	(0.051)	0.527	***	(0.059)	0.347	***	(0.043)	-0.203	***	(0.060)
female	-0.310		(0.612)	0.451		(0.543)	-0.337		(0.404)	0.165		(0.687)
chem	0.997	***	(0.359)	1.450	**	(0.599)	1.266	***	(0.254)	0.294		(0.273)
me	0.258		(0.348)	1.292	**	(0.533)	0.897	***	(0.256)	0.138		(0.283)
ee	0.768	*	(0.393)	1.509	***	(0.539)	0.840	***	(0.274)	-0.156		(0.307)
it	-0.019		(0.772)	1.645	**	(0.752)	0.856	*	(0.450)	-0.702		(0.542)
phys	0.547		(0.403)	1.022	*	(0.536)	0.491		(0.317)	0.043		(0.305)
othfield	0.067		(0.882)	2.271	***	(0.601)	0.689		(0.420)	-0.112		(0.837)
cons	-59.154		(38.540)	-45.843		(44.507)	-92.960	***	(21.813)	-79.582	***	(25.605)
n = 5151; Pseudo R2 = 0.1935; P > Chi2 = 0.0000; significance levels ***/**/*: α = 1 / 5 / 10%												
reference scientific field: life sciences; reference type of university: full university with medical school												

Table 6: Model 1; multinomial logit regression (base category: university ownership); national dataset; robust standard errors adjusted for multiple patents per inventor.

Model 2	non-profit (2)			uni+firms (3)			firms (4)			individuals (5)		
variables	coeff.		std.err.	coeff.		std.err.	coeff.		std.err.	coeff.		std.err.
lawexpcoh12	-1.602	***	(0.235)	-0.049		(0.328)	-1.308	***	(0.136)	-2.251	***	(0.161)
lawexpcoh3	-3.515	***	(0.549)	-0.774	*	(0.432)	-2.811	***	(0.288)	-4.025	***	(0.402)
unifirstpat	0.004		(0.010)	0.010		(0.012)	0.016	***	(0.006)	0.039	***	(0.008)
epo	1.384	***	(0.344)	0.610		(0.506)	1.629	***	(0.249)	0.341		(0.307)
famsize	0.145	***	(0.039)	0.060		(0.065)	0.206	***	(0.030)	0.030		(0.039)
numipc	0.009		(0.024)	-0.010		(0.031)	0.041	**	(0.016)	0.022		(0.019)
fh	-0.034		(0.423)	-0.460		(0.479)	-0.466	*	(0.272)	-0.223		(0.322)
techuni	-0.205		(0.306)	-0.592	*	(0.346)	-0.178		(0.198)	0.208		(0.225)
phdyear	0.013		(0.015)	0.019		(0.020)	0.017	**	(0.008)	-0.008		(0.011)
phdabroad	-1.585	***	(0.494)	0.573		(0.511)	-0.148		(0.404)	-1.394	**	(0.547)
multprofs	-1.768	***	(0.348)	-1.356	***	(0.506)	-1.792	***	(0.212)	-0.572	**	(0.252)
invcount	0.389	***	(0.051)	0.525	***	(0.059)	0.348	***	(0.043)	-0.203	***	(0.060)
female	-0.240		(0.618)	0.428		(0.541)	-0.251		(0.402)	0.222		(0.698)
chem	1.075	***	(0.367)	1.393	**	(0.593)	1.357	***	(0.256)	0.357		(0.275)
me	0.360		(0.338)	1.251	**	(0.521)	1.013	***	(0.266)	0.220		(0.275)
ee	0.923	**	(0.392)	1.431	***	(0.515)	1.025	***	(0.277)	-0.025		(0.300)
it	0.077		(0.756)	1.586	**	(0.748)	0.965	**	(0.452)	-0.626		(0.533)
phys	0.604		(0.406)	0.982	*	(0.537)	0.561	*	(0.312)	0.094		(0.300)
othfield	0.175		(0.885)	2.198	***	(0.584)	0.818	**	(0.409)	-0.024		(0.853)
cons	-37.426		(38.892)	-61.867		(40.650)	-66.524	***	(19.525)	-61.233	**	(25.156)
n = 5151; Pseudo R2 = 0.1901; P > Chi2 = 0.0000; significance levels ***/**/*: α = 1 / 5 / 10%												
reference scientific field: life sciences; reference type of university: full university with medical school												

Table 7: Model 2; multinomial logit regression (base category: university ownership); national dataset; robust standard errors adjusted for multiple patents per inventor.

Model 3	non-profit (2)			firms (4)			individuals (5)		
variables	coeff.		std.err.	coeff.		std.err.	coeff.		std.err.
law	-1.619	***	(0.395)	-1.288	***	(0.220)	-2.010	***	(0.261)
da	2.119	**	(1.011)	2.305	***	(0.612)	3.338	***	(0.625)
mr	-0.617		(0.830)	1.813	***	(0.386)	1.716	***	(0.560)
jena	1.330	*	(0.762)	0.786	*	(0.459)	0.736		(0.539)
stutt	2.028	***	(0.580)	1.409	***	(0.427)	2.335	***	(0.389)
tue	0.707		(0.614)	0.729	*	(0.382)	1.377	***	(0.448)
patexpcoh2	-0.565		(0.383)	-0.984	***	(0.303)	-0.505		(0.330)
patexpcoh3	-2.313	**	(1.149)	-0.856	**	(0.344)	-1.341	*	(0.739)
epo	0.160		(0.616)	2.400	***	(0.373)	1.936	***	(0.470)
famsize	0.045		(0.045)	0.139	***	(0.035)	0.034		(0.042)
numipc	-0.040		(0.038)	-0.048	*	(0.029)	-0.080	**	(0.038)
phdyear	0.044	*	(0.024)	0.032	**	(0.016)	-0.003		(0.019)
multprof	-0.673		(0.738)	-1.156	***	(0.284)	0.011		(0.338)
invcount	0.284	***	(0.080)	0.223	***	(0.064)	-0.282	***	(0.103)
female	-0.423		(1.042)	-0.758		(0.610)	-0.117		(0.796)
chem	0.163		(0.536)	-0.021		(0.359)	-0.139		(0.375)
me	-0.100		(0.688)	0.720	*	(0.402)	-0.374		(0.460)
ee	-0.910		(0.717)	-0.288		(0.553)	-1.254	**	(0.568)
it	0.869		(0.840)	0.270		(0.444)	-0.344		(0.712)
phys	0.327		(0.719)	0.288		(0.424)	-0.417		(0.547)
othfield	-2.168	*	(1.267)	1.044	*	(0.581)	0.213		(0.622)
cons	-87.946	*	(48.374)	-63.154	**	(31.111)	6.422		(38.200)
n = 1755; Pseudo R2 = 0.1786; P > Chi2 = 0.0000; significance levels ***/**/*: α = 1 / 5 / 10%									
reference scientific field: life sciences; reference university: TU Dresden									

Table 8: Model 3; multinomial logit regression (base category: university ownership); dataset of six universities; robust standard errors adjusted for multiple patents per inventor.

Model 4	non-profit (2)			firms (4)			individuals (5)		
variables	coeff.		std.err.	coeff.		std.err.	coeff.		std.err.
lawexpcoh12	-1.608	***	(0.397)	-1.269	***	(0.211)	-2.004	***	(0.262)
lawexpcoh3	-3.536	***	(1.135)	-1.593	***	(0.337)	-2.957	***	(0.709)
da	2.020	**	(1.018)	2.166	***	(0.671)	3.230	***	(0.644)
mr	-0.600		(0.853)	1.785	***	(0.390)	1.710	***	(0.553)
jena	1.376	*	(0.754)	0.783	*	(0.434)	0.787		(0.530)
stutt	1.997	***	(0.578)	1.367	***	(0.459)	2.313	***	(0.390)
tue	0.743		(0.626)	0.716	*	(0.406)	1.403	***	(0.455)
epo	0.120		(0.617)	2.353	***	(0.373)	1.963	***	(0.467)
famsize	0.046		(0.044)	0.136	***	(0.033)	0.033		(0.043)
numipc	-0.035		(0.038)	-0.039		(0.029)	-0.074	*	(0.038)
phdyear	0.032		(0.027)	0.011		(0.015)	-0.014		(0.019)
multprof	-0.652		(0.715)	-1.121	***	(0.279)	0.040		(0.348)
invcount	0.295	***	(0.082)	0.231	***	(0.065)	-0.277	***	(0.104)
female	-0.381		(1.067)	-0.705		(0.586)	-0.112		(0.781)
chem	0.304		(0.530)	0.219		(0.356)	0.001		(0.383)
me	0.120		(0.687)	0.970	**	(0.433)	-0.185		(0.468)
ee	-0.591		(0.685)	0.136		(0.564)	-0.949	*	(0.569)
it	1.119		(0.809)	0.565		(0.464)	-0.111		(0.666)
phys	0.291		(0.713)	0.187		(0.448)	-0.454		(0.539)
othfield	-2.184	*	(1.265)	0.921		(0.584)	0.167		(0.617)
cons	-66.071		(52.630)	-22.340		(30.448)	26.848		(37.519)
n = 1755; Pseudo R2 = 0.1696; significance levels ***/**/*: α = 1 / 5 / 10%									
reference scientific field: life sciences; reference university: TU Dresden									

Table 9: Model 4; multinomial logit regression (base category: university ownership); dataset of six universities; robust standard errors adjusted for multiple patents per inventor.

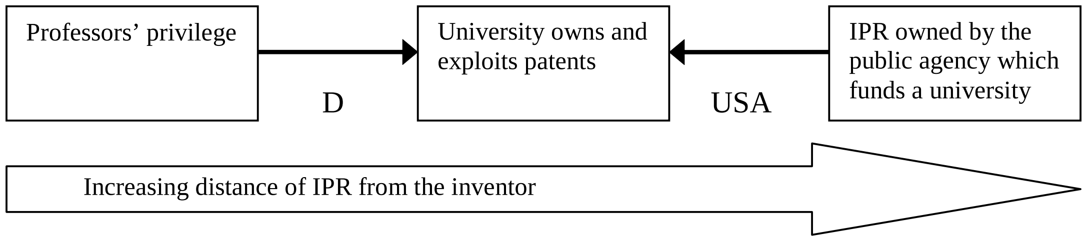

Figure 1: Change in IPR legislation in the USA and Germany.

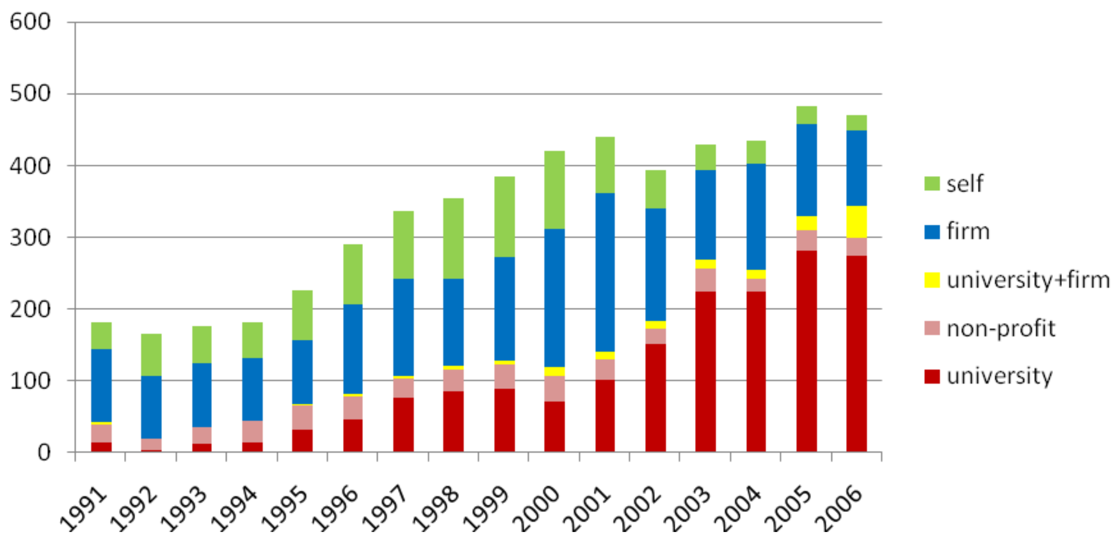

Figure 2: Development of patent applications in the individual ownership groups (national dataset).

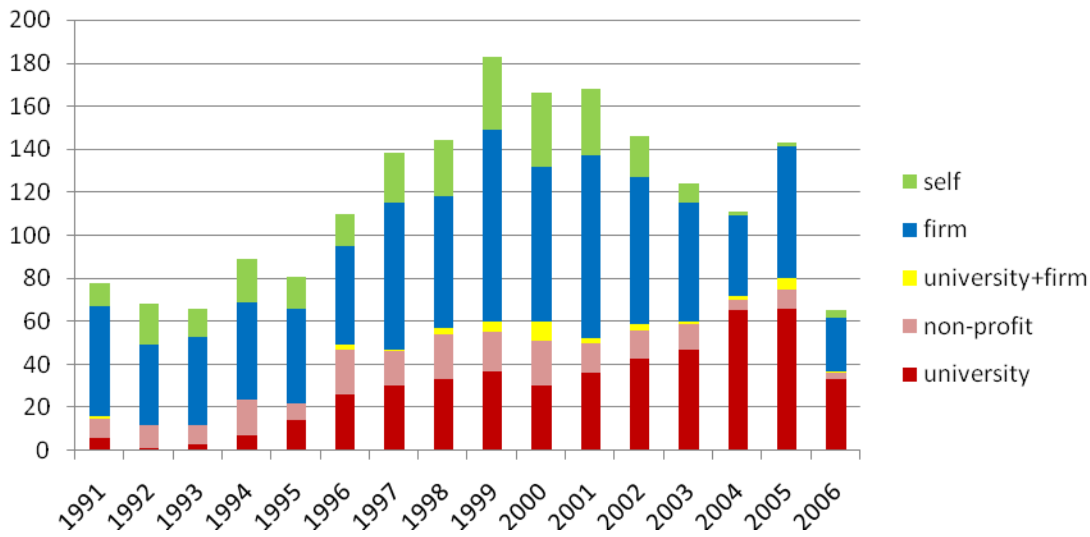

Figure 3: Trend of patent applications at the six selected universities.

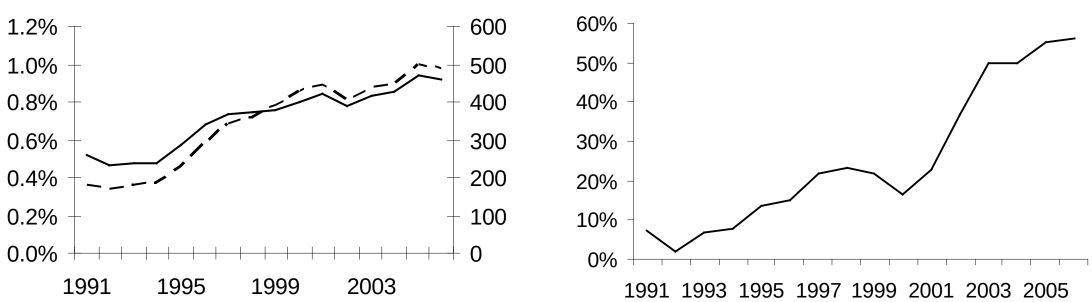

Figure 4: Development of patent applications 1991-2006 (national dataset). Left: Yearly shares of patents from our dataset of all German patents with German inventors (solid curve, left scale) and the absolute number of patents in the dataset (dashed curve, right scale). Right: Share of university-owned patents of all university-invented patents in the dataset. Source: DEPATISnet (own research) and DPMA (1998-2006).

Appendix: Additional Models

Model A1	non-profit (2)			uni+firms (3)			firms (4)			individuals (5)		
variables	coeff.		std.err.	coeff.		std.err.	coeff.		std.err.	coeff.		std.err.
law2002	-1.410	***	(0.344)	-0.004		(0.405)	-0.855	***	(0.178)	-1.321	***	(0.210)
law2003	-1.273	***	(0.256)	-0.340		(0.387)	-1.315	***	(0.181)	-2.150	***	(0.252)
law2004	-1.934	***	(0.391)	-0.481		(0.428)	-1.293	***	(0.171)	-2.326	***	(0.259)
law2005	-1.549	***	(0.367)	-0.304		(0.416)	-1.336	***	(0.242)	-2.694	***	(0.336)
law2006	-1.737	***	(0.325)	0.672		(0.469)	-1.695	***	(0.214)	-2.832	***	(0.297)
unifirstpat	0.006		(0.010)	0.006		(0.012)	0.018	***	(0.006)	0.041	***	(0.008)
patexpcoh2	-0.450	*	(0.239)	0.282		(0.384)	-0.549	***	(0.186)	-0.368	*	(0.189)
patexpcoh3	-2.208	***	(0.570)	-0.517		(0.462)	-1.837	***	(0.297)	-1.996	***	(0.417)
epo	1.446	***	(0.346)	0.551		(0.536)	1.698	***	(0.253)	0.457		(0.316)
famsize	0.126	***	(0.039)	0.085		(0.056)	0.185	***	(0.029)	0.003		(0.040)
numipc	0.007		(0.023)	0.002		(0.029)	0.036	**	(0.016)	0.017		(0.018)
fh	-0.123		(0.425)	-0.368		(0.479)	-0.565	**	(0.274)	-0.290		(0.323)
techuni	-0.196		(0.306)	-0.655	*	(0.358)	-0.163		(0.198)	0.210		(0.226)
phdyear	0.025		(0.015)	0.009		(0.019)	0.030	***	(0.009)	0.002		(0.012)
phdabroad	-1.432	***	(0.479)	0.412		(0.538)	0.059		(0.396)	-1.254	**	(0.535)
multprofs	-1.759	***	(0.348)	-1.425	***	(0.509)	-1.789	***	(0.208)	-0.577	**	(0.248)
invcount	0.389	***	(0.051)	0.537	***	(0.061)	0.349	***	(0.043)	-0.196	***	(0.061)
female	-0.344		(0.612)	0.538		(0.528)	-0.375		(0.400)	0.131		(0.655)
cons	-62.697		(38.71)	-36.106		(44.43)	-96.771	***	(22.23)	-84.375	***	(25.88)

n = 5151; Pseudo R2 = 0.1975; significance levels ***/**/*: α = 1 / 5 / 10%
Scientific fields included (not reported); reference type of university: full university with medical school

Model A1: multinomial logit regression (base category: university ownership); national dataset; robust standard errors adjusted for multiple patents per inventor.

Model A2	non-profit (2)			uni+firms (3)			firms (4)			individuals (5)		
variables	coeff.		std.err.	coeff.		std.err.	coeff.		std.err.	coeff.		std.err.
lawexpcoh12	-1.149	***	(0.341)	-0.087		(0.523)	-1.258	***	(0.200)	-2.087	***	(0.273)
lawexpcoh3	-3.072	***	(0.577)	-0.800		(0.586)	-2.756	***	(0.317)	-3.875	***	(0.456)
unifirstpat	0.004		(0.010)	0.010		(0.011)	0.016	***	(0.006)	0.039	***	(0.008)
privepo	3.798	***	(1.035)	3.111	**	(1.445)	3.738	***	(0.997)	2.581	**	(1.040)
lawepo	0.711		(0.599)	0.323		(0.559)	1.464	***	(0.292)	-0.103		(0.398)
privfamsize	0.116	***	(0.039)	0.087		(0.061)	0.165	***	(0.032)	-0.003		(0.042)
lawfamsize	0.055		(0.085)	0.024		(0.116)	0.300	***	(0.053)	0.064		(0.094)
privnumipc	0.052		(0.032)	-0.061		(0.086)	0.089	***	(0.027)	0.063	**	(0.027)
lawnumipc	-0.017		(0.038)	0.002		(0.027)	-0.004		(0.021)	-0.015		(0.035)
fh	-0.040		(0.416)	-0.475		(0.483)	-0.454	*	(0.273)	-0.219		(0.319)
techuni	-0.202		(0.305)	-0.591	*	(0.350)	-0.169		(0.198)	0.210		(0.224)
phdyear	0.013		(0.015)	0.019		(0.020)	0.017	**	(0.008)	-0.008		(0.011)
phdabroad	-1.600	***	(0.479)	0.557		(0.496)	-0.144		(0.395)	-1.399	***	(0.542)
multprofs	-1.786	***	(0.347)	-1.368	***	(0.505)	-1.812	***	(0.214)	-0.575	**	(0.252)
invcount	0.393	***	(0.051)	0.526	***	(0.060)	0.350	***	(0.043)	-0.202	***	(0.060)
female	-0.243		(0.619)	0.441		(0.557)	-0.282		(0.391)	0.204		(0.696)
chem	1.054	***	(0.364)	1.417	**	(0.597)	1.355	***	(0.256)	0.353		(0.275)
me	0.324		(0.333)	1.258	**	(0.534)	0.997	***	(0.267)	0.199		(0.273)
ee	0.913	**	(0.391)	1.457	***	(0.525)	1.005	***	(0.275)	-0.040		(0.296)
it	0.028		(0.75)	1.589	**	(0.754)	0.965	**	(0.45)	-0.636		(0.53)
phys	0.566		(0.409)	0.972	*	(0.546)	0.542	*	(0.312)	0.068		(0.297)
othfield	0.154		(0.879)	2.193	***	(0.594)	0.786	*	(0.416)	-0.048		(0.845)
cons	-37.609		(38.65)	-61.316		(40.969)	-67.482	***	(19.49)	-61.698	**	(24.84)
n = 5151; Pseudo R2 = 0.1935; significance levels ***/**/*: α = 1 / 5 / 10%												
reference scientific field: life sciences; reference type of university: full university with medical school												

Model A2; multinomial logit regression (base category: university ownership); national dataset; robust standard errors adjusted for multiple patents per inventor.