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

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Abstract: We analyse academic patenting in Germany before and after the abolition of the 'professors' privilege' in 2002 to explore how the legal change affected patenting behaviour. Individual-level data show a shift from individually-filed and company-filed patents to university-filed patents, with increasing strength over the years. The patent experience of both inventors and their employing universities further explain the variance in assignment patterns.

JEL Classifications: O33, O34, O38
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1. Introduction

Throughout the industrialized world, the importance of public research for the innovation performance of countries and regions has often been emphasized in the past decades. In addition to their teaching and research missions, universities have increasingly been recognized as providers of knowledge inputs into private-sector innovation processes (cf. Jaffe, 1989). Among policy makers there has been a widespread concern that the capabilities of universities to support private-sector innovations are 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.

Time and again, these concerns have induced 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 (IPR) in 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 had developed in research funded by federal agencies. This IPR regime replaced a complex network of bilateral agreements between individual sponsoring agencies and universities 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, and in individual cases universities were able to secure substantial rents from licenses and patent sales.

There is strong empirical evidence suggesting that the increased patenting activities are at most partially due to the Bayh-Dole Act. Yet this legal change has nonetheless been emulated by policy makers in other countries, reflecting a belief in the importance of IPR-based technology transfer organized through university administrators. Germany was among the countries that adopted a Bayh-Dole-like IPR regime for university inventions. In 2002, a special clause in the law on employee inventions (*Arbeitnehmer-*

erfindungsgesetz) was abolished that had excluded university researchers from the general obligation of employees to disclose job-related inventions to their employers who could then claim ownership in the invention. This exclusion, which allowed university researchers to retain the ownership in their inventions, had been known as the professors' privilege (*Hochschullehrerprivileg*).

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.)

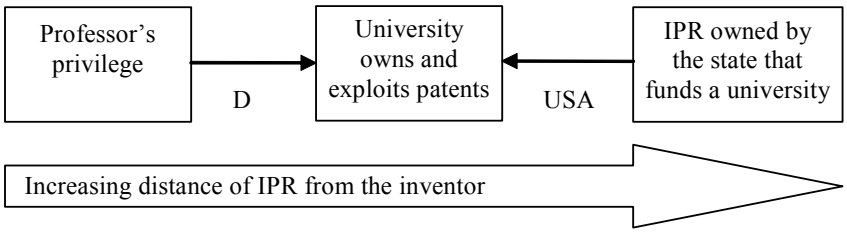

Figure 1: Change in IPR legislation in the USA and Germany.

In Germany, the suspicion was not that university inventions might be shelved because of too much red tape frustrating IPR negotiations between university administrations and federal agencies. Rather, 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 these tasks, and accordingly the change in the legal treatment of university inventions was complemented by substantial federal subsidies for newly established TTOs. At the same time, the scope of the German reform exceeded that of its U.S. model. To date, there is no legal mandate in the U.S. that would require university researchers to disclose inventions to their employer. And while most universities enforce disclosure through their employment contracts, this is not universally the case.

There has been an extensive scholarly discussion on the empirical effects of the Bayh-Dole Act (cf. e.g. Mowery et al. 2001). In spite of this prior work, empirical analysis of

the German reform is justified because, as was shown in the last paragraph, the German reform did not emulate the U.S. reform as closely as it seemed at first glance. There are further idiosyncratic elements of the German public research system and its IPR regime that also limit the extent to which the sparse empirical evidence on reforms in other European countries (largely limited to the pioneering work by Valentin and Jensen, 2007 and by Della Melva et al., 2008) can be generalized to the German case. First, there is a unique division of labor between universities and non-university public research organizations. As the latter were not subject to the professors' privilege before 2002, there existed a hybrid IPR regime, which may affect the outcomes of the post-2002 reform. Second, qualitative evidence shows that a technology transfer infrastructure was established before 2002 at some universities, and even though mandatory disclosure was inexistent, a substantial number of patents were owned by universities. Third, and related, in the Eastern parts of post-reunification Germany, norms and attitudes toward university inventions may differ from those in the West, since before 1990 socialist East Germany had not known a professors' privilege, and organized technology transfer was part of the mission of East German universities that were much less autonomous than their Western counterparts (cf. Albrecht, 2001, for an illustrative historical case study).

Even though the above considerations suggest that studying the effects of the German reform of 2002 is important, doing so is considerably complicated by the difficult access to the relevant data. Given the historical IPR regime, most university-invented patents were not owned by the universities before 2002. Similar to other European countries, this necessitates a search for university inventors rather than university-owned patent (cf. Lissoni et al., 2007). At the same time, for institutional reasons outlined in section 3 identifying university researchers in patent databases is less straightforward than elsewhere. To deal with this challenge, we analyze university patents identified through a variant of the method pioneered by Becher et al. (1993) and Abramson et al. (1997) which is based on the professor title of inventors in patent databases. Our results suggest an overall greater propensity of the professors to assign patents to their university. Importantly, we find some evidence that the new legislation disturbs existing industry links. Finally, there seems to be path-dependency in the development of transfer

activities: professors at universities with a longer tradition in patenting use more often university support.

The remainder of this paper is structured as follows. Based on prior findings as well as theoretical considerations, in section 2 we develop a set of hypotheses about expected effects of the abolition of the professors' privilege. The dataset underlying our study, as well as the 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, Institutions, and Patent Applications: Expected Effects of the 2002 Legal Changes

Not all patents based on inventions made by university researchers are owned by universities. Based on the applicant (assignee) of the patent, the broad group of university-invented patents (sometimes called academic patents; see Sapsalis and van Pottelsberghe, 2007; we will also use the term university patents) can be divided into university-owned, company-owned and individually-owned patents. Patents may also have multiple assignees, e.g. some patents are jointly owned by a university and a private-sector company. We will furthermore distinguish between inventors from universities and from non-university public research organizations, as the latter were not affected by the legal change of 2002.

Patenting professors can be expected to have modified their behaviour after 2002 because the legal change directly affected their incentives. Under the old legal regime, university inventors could freely decide if and through what channels to apply for patents. If they applied for a patent in their own name, they had to bear the substantial costs and efforts of the application process themselves, and likewise they had to find a licensee to commercialise their invention. The reform of 2002 was enacted on the presumption that many researchers were deterred from technology transfer activities under these conditions, instead limiting themselves to their traditional research and teaching tasks.

However, if they were able to sell their patent or find a licensee, inventors retained all of the ensuing income. Thus, patenting was a risky but potentially quite lucrative activity.

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, and the remuneration of the university inventor based negotiated between the two parties.

Finally, as was pointed out above, the empirical record shows that even without a legal requirement to disclose inventions to the employer, some universities owned patents on inventions made by their professors, which reflects the establishment of a TTO prior to 2002 and the willingness of professors to utilize the official channels of technology transfer at these universities.

After 2002, inventing professors face substantially shifted financial incentives. With the universities owning their inventions, inventors no longer have to bear the financial burden of the patent application, but the law requires universities to pay for all ensuing costs. In principle, universities can give back the IPR to the inventor, but given university incentives (see below) this is unlikely to be a regular outcome. Effectively, the new legislation insures university inventors without private-sector partners against the financial risk coming with patent applications. In addition, a well-functioning TTO may increase the likelihood that an invention is successfully licensed and thus generates a positive income for the inventor.

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 commercialised inventions now generate for their inventors. The law mandates that inventors receive 30% of the gross income the university generates from commercialising their inventions. This is considerably more than private-sector firms normally pay their employee inventors, but of course much less than the 100% that the inventors used to get before.

In summary, then, the incentive effects of the new law differ with the expected licensing income. On the one hand, the threshold for professors to engage in patenting activities should have become lower because of the reduced financial risks, possibly further reinforced by enhanced technology transfer awareness and the newly established TTO infrastructure accompanying the 2002 reform. This should increase the number of patent applications based on inventions made by university researchers (irrespective of ownership). On the other hand, professors at the top end of expected pay-offs, in particularly those who are experienced inventors, now face reduced expected incomes, which will reduce their willingness to engage in patenting. We expect that the positive effect dominate the negative ones, which motivates the following hypothesis on the overall development of university-invented patents:

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

The effects of the new legislation are different for researcher-inventors who collaborate with private-sector firms and used to assign their patents to the private-sector partner. In principle, this is still possible, provided the underlying invention was not made as part of their 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 company and the university's TTO. 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. In any case, the existence of a third party (the university) will likely complicate negotiations with private-sector firms as compared to the earlier situation when professors could freely decide how to exploit their inventions.

Further adding to these complications is that the incentives faced by the universities also have changed as well. The new legislation requires them to engage in technology transfer activities, which can be signalled by large numbers of patent applications. Reputation and the hope to find the "nugget" are responsible for the engagement as well as the expectations of policy makers. Due to the impossibility to know a patent's value in advance universities file patents rather than given the IPR back to the inventor. Thus, we

expect the share of university-owned patents among all university-invented patents to increase as well.

Hypothesis 1b: The share of university-owned patents of all university-invented patents increases after 2002.

The different ownerships of patents invented with university knowledge were not regarded when policy and researcher attention first lay on the commercialization of public research. The "European Paradox" seemed to be existent: Europe was perceived as strong in science but weak in the commercialization of research results, because there were only few patents filed by universities. However, economic research was able to show that the technological application of science does not lag behind the USA (cf. Tijssen and van Wijk, 1999; Verspagen, 2006).

Because there was patent activity already before the legal change, one can expect to observe shifts in assignment patterns brought about by the law. In particular, individually filed patents have become particularly unattractive following the new legislation. They should only be observed in cases where the university gave the invention back to the inventor after a negative assessment of its commercialisation odds, or in illegitimate cases of TTO circumvention.

Hypothesis 2a: The share of individually-filed patents decreases strongest after 2002.

A focus on university-owned patents may moreover deter private-sector firms from working with university researchers, because it generates uncertainty with regard to the ensuing IPR. Even if this does not lead to overall reductions in the number of university-invented patents (which would counteract the development conjectured in hypothesis 1; cf. the work on Danish biotechnology patents by Valentin and Jensen, 2007), it will still be reflected in a reduced share of company-owned patents.

Hypothesis 2b: Due to a better enforcement of the universities' property rights by TTO staff the shares of patents owned by companies or public research institutions decrease as well.

As discussed above, the new law is especially useful for those professors who never engaged in patent activities because they avoided the time-effort and the financial risk. They probably did not have industry links useful for commercialisation activities. They can now rely on the TTO infrastructure and can be expected to assign patents to a university most often.

Hypothesis 3: The effect of the reform is stronger on researchers who have no patent applications before 2002.

Company ownership of patents has some advantages in the transfer process. Companies usually have more experience with patents and face less budget constraints. If the invention emerged out of collaborative research, it is probably of higher quality because more people with more diverse knowledge participated. At the same time, the commercial application is easier when company researchers have been involved. They are better informed about the technology, which they will develop into a product then. The greater engagement of the company in the commercialisation process increases the value of the patents. Crespi et al. (2006) find some evidence that companies commercialise inventions more efficiently than universities. The direction of causality between higher value and company involvement can not be decided without further investigation, but it can be expected that there is a correlation.

Hypothesis 4: Patents of higher quality belong to companies.

Previous literature found that universities' commercialisation infrastructure is an important determinant of their professors' patent activities. The individual willingness to engage in patenting with support of the university as well as the university's capability to screen professors' research for patentable output and to provide inputs to the application process depend on the quality, age, and size of the technology transfer office (TTO).[1] Well-functioning TTOs do not only require well-trained (and competitively paid) staff, but also a close relationship to industry based on personal contacts, networks, and experience with what firms specialise in a given field and could thus be interested in licensing university-owned patents. This needs time to evolve. Huelsbeck and Menno

1 Cf. Friedman and Silberman (2003) for an overview of studies on these factors.

(2007) study the patenting activities of German universities in three periods (1981-1993; 1994-2001; 2002-2006) and find a significant influence of the university's patent experience (measured by the time elapsed since the first patent application) on the number of its patent applications during the time of the professors' privilege. In the post-reform period, the number of patents filed in earlier time periods has a significant positive influence. Both the age of the first patent application and the number of previous applications are measures of experience and of the path dependency.

Hypothesis 5: The more patenting experience a university has, the more university-invented patents are assigned to it.

3. Datasets and Empirical Approach

3.1 Database

Non-university-owned patents with academic background are difficult to find. For several European countries, the *KEINS* project solved the problem by collecting and analysing full staff lists of the universities (cf. Lissoni et al. 2007). Germany is not included among the studied countries. Using this approach for Germany is moreover complicated by two institutional factors. First, the German university system is highly decentralised, with the *Länder* being in charge of educational issues. As a consequence, staff lists would have to be obtained from 16 individual regional administrations rather than the Federal government. Second, privacy issues are taken very seriously in Germany, further reducing the likelihood to obtain official staff lists.

To address this challenge, we make use of the fact that in Germany academic titles are seen as a part of individuals' names. Indeed, 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 Abramson et al. (1997). 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, titles may not be used consistently in patent applications, in particular application of patents that are not university-owned. Second, many top-level R&D staff of German companies, in particular large and R&D-intensive ones, hold honorary professorships at German universities. The same holds for the top-level researchers of non-university public research organizations such as the Fraunhofer, Leibniz or Max Planck Societies. Both groups of individuals are not affected by the 2002 reform.

We therefore searched for additional information on the internet for all 1,300 professors we had originally identified as inventors of university patents and excluded all inventors who were not full-time university employees. We also excluded researchers who retired before 2004 to include only those individuals who experienced some years of the professors' privilege as well as some years of the new legislation. Finally, we checked for homonyms on the basis of comparing residences, assignees, and technology classes of patents. We also searched for the inventors' gender, year of the PhD, and year of their first patent application, and also for their employing university and its first patent application. These searches were facilitated by the fact that homonyms are less widespread in German-speaking countries than elsewhere, and our database includes only a few individuals who have widespread family names.

Note that our data do not include academic inventors who never had a patent owned by a university. Conceivably, these individuals have *bona fide* patenting activities based on collaborative inventions and/or consulting activities (Thursby et al., 2007). To evaluate the effects of the legal changes on these individuals, in companion work we conducted patent searches for the entire population of professors at six selected universities. This research gives evidence that we cover only about 60% of public universities' professors active before and after 2002 and about 70% their patents.

The remaining 986 professors we then searched individually, i.e. all their patent applications with German or European priority in the period 1991-2006 were collected in a database (irrespective of whether or not the title is used in the individual application). The assignees of these patents were then categorised into 7 groups: (1) German universities (if applicable: jointly with individual persons); (2) non-profit organisations

except German universities; (3) universities jointly with a company, (4) companies, (5) individuals; (6) joint applications of universities and non-profit research organisations; (7) companies which employed the (future) professor at the time of the patent application. The last group of patents (7) is of no interest for our analysis because these patents are not academic patents, but they are relevant when searching for the year an inventor engaged in patent activities for the first time. We then added to each patent the according inventor and university information.

Our dataset is a magnitude smaller than that collected by Schmoch (2007) in his work on German university-invented patents. Some of this discrepancy is due to the fact that individuals without any university-owned patents are missing from our data. This alone cannot account for the difference, however. Looking at the data in more detail, we found that compared to Schmoch (2007) we have a similar amount of university-owned patents, but too few company-owned and individually filed patents.

Suspecting that honorary professors who are full-time employees of private-sector firms might be one factor underlying the differences, we searched for professors appearing on the patent applications of four of the most patent-active German companies (Siemens, Bosch, BASF, Bosch-Siemens-Hausgeräte). This indicated that honorary professors holding management jobs in the R&D departments of these companies account for almost 50% of the patents owned by the respective firms that have a professor among their inventors. In addition, retired professors and those working at foreign universities or non-university public research institutes each account for another 10% of the patents.

Among the individually filed patents we did not find highly patent active researchers. There are a large number of medical professors working at non-university hospitals, individuals working in firms of their own, and also many individuals for which we were unable to obtain any information on the Internet, which suggests they are not active university researchers. Altogether, in a sub-sample of 100 professors with own patents, 70% of all patents did not fall into categories for the analysis. Therefore, our samples of firm-owned and individually filed patents suggest that our dataset largely covers the relevant population of university-invented patents.

3.2 Descriptive statistics

We collected a total of 5,624 patents of which 453 had more than one of our 986 professors among their inventors. If we count the respective patents multiple times, the average number of patents per professor is 6.21 (median is 4). For the analysis, we always use the individual and university data of the oldest professor (earliest year of PhD). By this we implicitly assume the oldest one to have the greatest influence on what happens with the patent. German priority was the normal case with 5,195 patents, 429 had European one. Of those with German priority, 1,533 had additional publication documents with a European number, thus we have 1,962 European patents. The average patent active professor in Germany therefore has 2 European patent applications.

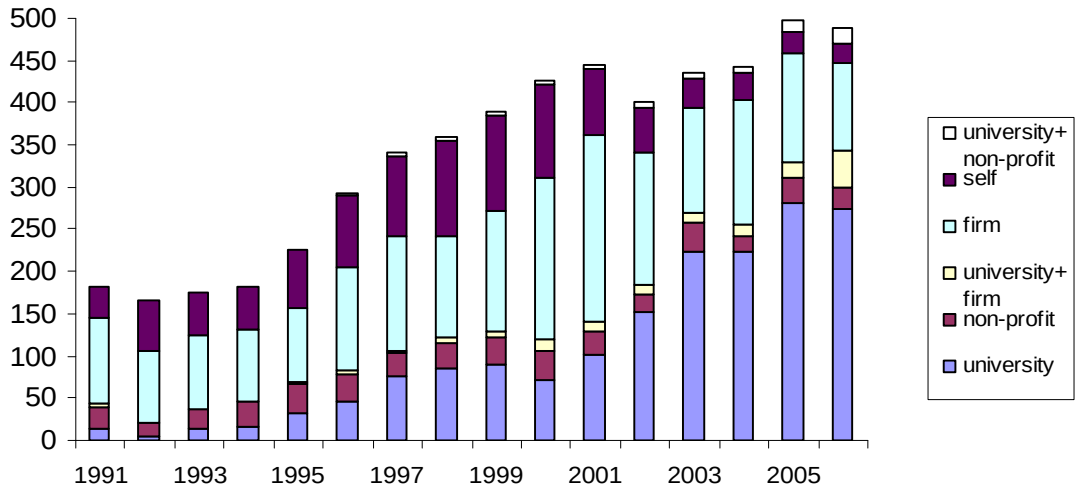

Figure 2: Development of patent applications in the individual groups of assignment.

There are 111 company-patents of 22 (future) professors who were at that time employed at the respective company (group 7). These patents are of no use for our analysis and excluded in the following. Additionally, 64 patents with combinations of (2)+(4) and (1)+(2)+(4) were excluded in order to avoid too many groups. For merging these patents with one of the other groups one would have to make assumptions which could weaken our results if not true. Figure 2 shows that company-owned patents dominate among the

remaining patents.[2] For simplicity, patents from non-university non-profit institutions are labelled non-profit in the following in order to summarize public and private research institutions.

The yearly patent applications in our database have a positive trend over the whole period – with a temporary decline from 2002 to 2004. In contrast to Schmoch (2007) we do not find a sustained decrease after 1999. This discrepancy reflects the specificities of our database and will be discussed below. But apparently, the increase in academic patenting slowed down since 2001.

Tables 1 and 2 list the variables we collected and some corresponding descriptive statistics. There are two possible measures for controlling the field of research: the IPC section of the patent application, and the reseachers' departments. In case of interdisciplinary departments we checked for the field of the PhD in the database of the German National Library, where all PhD theses in Germany are recorded, including the year of the PhD.

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	2231
uni_firstpat	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	3015
patexpcoh2	dummy taking the value one if the inventor filed his first patent between 1991 and 2001	2105
patexpcoh3	dummy taking the value one if the inventor filed his first patent after 2001	329
Further explanatory variables		
EPO	dummy taking the value one for patents with European priority	403
famsize	number of 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 database among the inventors	444
phdyear	year of the PhD of the professor	
Control variables		
female	dummy taking the value one if the inventor is female	84
phdabroad	dummy taking the value one if the PhD is from a non-German	222

2 The slightly lower number for 2006 compared to 2005 can be explained by delayed publication of patent documents. When filing a patent internationally documents are often published with delay.

	university	
techuni	dummy taking the value for universities with technical specialisation	1781
uni	dummy taking the value one for research universities that are no technical universities	3142
fh	dummy taking the value one for universities of applied sciences (Fachhochschulen)	492
othcat	dummy taking the value one for all other employers, e.g. non-university hospitals	34
A – H	IPC section dummies	
me	dummy taking the value one for professors for mechanical engineering	1327
ee	dummy taking the value one for professors for electrical engineering	699
chem	dummy taking the value one for professors for chemistry	1188
phys	dummy taking the value one for professors for physics	519
med	dummy taking the value one for professors for medical and pharmaceutical sciences	958
bio	dummy taking the value one for professors for biology	390
it	dummy taking the value one for professors for IT and mathematics	146
othfield	dummy taking the value one for professors for anything else	182

Table 1: List of variables with frequencies of the dummy variables taking the value 1.

variable	obs	mean	s.d.	min	max
famsize	5449	1.81	3.27	0	32
invcount	5449	3.48	1.81	1	15
phdyear	4994	1979	8.58	1955	2003
ipc	5449	3.98	3.98	1	67
uni_firstyear	5418	1984	14.9	1957	2006

Table 2: Summary statistics of integer variables.

The method we apply in our analysis is a multinomial logit regression, where the probability of a patent to be assigned to the categories of ownership in comparison to one base category is calculated. With the same methodology, Thursby et al. (2007) study why 20% of academic patents in the US are solely assigned to companies in spite of the law assigning the rights to the university. They find individual characteristics to be responsible for company ownership of academic patents.

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

Figure 3 (left) shows an increase of university-invented patents during most of the time period observed. The graphical observation does not suggest a special influence of the legal reform and we can not clearly decide about hypothesis 1a. Much steeper is the

increase in the share of university-owned patents among all university-invented patents in our database. In figure 3 (right) we can see how this share increased from 2002 onwards, after it had been stagnating for several years. Thus, the data provide initial support to hypothesis 1b.

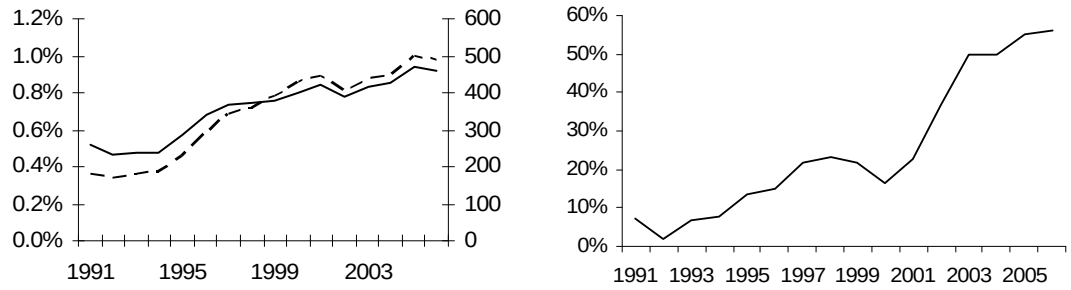

Figure 3: Left: Yearly share of patents from our database of all German patents with German inventors (solid curve, left scale) and the absolute number of patents in our database (dashed curve, right scale).[3] Right: Share of university-owned patents of all university-invented patents in our database.
Source: depatisnet (own research) and DPMA (1998-2006)

Regarding the sum of absolute numbers of university-owned and company-owned patents (groups 1, 3, and 4), there is an average yearly increase of 18.6% from 1994 to 2001, which is reduced to 6.6% from 2001 to 2005. Adding individual, university, and company applications (groups 1, 3, 4, and 5), the increase decreases from 15.4% yearly to 2.6%.[4] These data indicate that the number of university-owned patents increases at a slower rate than company-owned and individually-owned patents decrease.

In order to test the remaining hypotheses, we use multinomial logit models. The probability of a patent to be assigned to each of our groups of ownership is compared to university ownership. 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 their employing universities. To proxy individual experience, the inventors are divided into three cohorts based on the

3 Note, that according to Verspagen (2006) the share of university-invented patents is at least 3% in Germany. In section 3 we discussed what particularities of the database lead to lower figures.

4 Cf. dashed line in figure 3 (left). This line contains additionally groups 2 and 6, which have relatively constant (and low) numbers during the period of observation.

years of their 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.[5] Further explanatory and control variables are added on the patent, university, and inventor level. We use department affiliations rather than IPC sections to measure fields of research because prior estimations showed them to have more explanatory power.

Due to the small number of patents jointly owned by a university and a non-profit organization, we omit these patents. Patents where the employer of the professor is no university but, e.g., a hospital (*othcat*) are merged with the base category of university-owned patents. This seemed most plausible, as medical scientists have most often worked at research universities before being employed at different hospitals. In all specifications, there are no differences between male and female inventors and the respective variable is skipped. The third variable omitted is the dummy for professors of biology (*bio*). In spite of rather low standard errors these patents to not differ from medical and pharmaceutical ones. The disciplines can all be summarized as life sciences and therefore we merge *bio* and *med*, which then together form the base category. This results in model 1 in table 3 below. Many variables are significantly influencing the kind of assignee. [6]

5 The rationale for the different approach towards individual and institutional experience is that for most inventors, we have the first patent among our data while in the case of the universities, this is less often the case because the first patent application more often comes from an inventor not included in our database.

6 We have full information only for 4,889 patents, but when excluding the variables where information is missing (mainly *phdyear*) the values of the other variables hardly change, i.e. the model is robust.

Model 1	non-profit (2)			univ.+company (3)			companies (4)			Individuals (5)		
variables	coeff.		std.err.	coeff.		std.err.	coeff.		std.err.	coeff.		Std.err.
Law	-1.566	***	(0.135)	-0.034		(0.210)	-1.287	***	(0.089)	-2.261	***	(0.115)
unifirstpat	0.006		(0.004)	0.004		(0.007)	0.017	***	(0.003)	0.038	***	(0.004)
patexpcoh2	-0.445	***	(0.139)	0.253		(0.225)	-0.528	***	(0.096)	-0.383	***	(0.110)
patexpcoh3	-2.123	***	(0.527)	-0.574		(0.380)	-1.850	***	(0.224)	-2.009	***	(0.405)
Fh	-0.186		(0.236)	-0.353		(0.372)	-0.608	***	(0.165)	-0.334	*	(0.180)
techuni	-0.194		(0.154)	-0.692	***	(0.241)	-0.241	**	(0.106)	0.245	*	(0.126)
phdyear	0.022	***	(0.008)	0.014		(0.012)	0.031	***	(0.006)	0.004		(0.006)
phdabroad	-1.594	***	(0.541)	0.448		(0.393)	0.060		(0.216)	-1.389	***	(0.370)
multprofs	-1.854	***	(0.257)	-1.466	***	(0.351)	-1.858	***	(0.160)	-0.550	***	(0.170)
invcount	0.381	***	(0.035)	0.521	***	(0.047)	0.349	***	(0.027)	-0.214	***	(0.036)
epo	1.282	***	(0.248)	0.596		(0.407)	1.589	***	(0.182)	0.252		(0.263)
famsize	0.133	***	(0.025)	0.043		(0.051)	0.200	***	(0.020)	0.023		(0.024)
numipc	-0.002		(0.020)	-0.007		(0.033)	0.038	***	(0.014)	0.018		(0.016)
chem	0.958	***	(0.182)	1.258	***	(0.319)	1.186	***	(0.131)	0.175		(0.155)
me	0.267		(0.204)	1.155	***	(0.338)	0.792	***	(0.136)	0.076		(0.153)
ee	0.925	***	(0.222)	1.362	***	(0.396)	0.983	***	(0.158)	-0.061		(0.179)
it	0.116		(0.473)	1.757	***	(0.485)	0.980	***	(0.244)	-0.595	*	(0.352)
phys	0.485	**	(0.230)	0.964	***	(0.376)	0.566	***	(0.158)	0.024		(0.177)
othfield	-0.064		(0.456)	2.196	***	(0.452)	0.722	***	(0.254)	-0.133		(0.286)
cons	-58.755	***	(17.867)	-42.046		(27.594)	-96.721	***	(12.211)	-83.109	***	(14.261)

Table 3: Model 1; n = 4889, Pseudo R2 = 0.1915, Log likelihood = -5360.4; significance levels ***/**/*: α = 1 / 5 / 10%.

The primary result is the effect of the abolition of the professors' privilege. We find that, in line with hypothesis 1b, patents are much more probable to be assigned to a university after the reform of 2002. The higher propensity towards university-owned patents could be a short-run effect in the year after the enactment of the law. But subdividing the *law* variable into yearly dummies (*law2002-law2006*) reveals a reinforcing trend: in 2006 the probability for a patent to be assigned to a company or an individual person is twice as low as in 2002 (see model A1 in the appendix). There is no such trend for non-profit patents; for joint applications of universities and companies the variables stay insignificant.

The strongest effect can be seen for individually filed patents. This supports hypothesis 2a. The assignment to companies and non-profit organisations decreased as well, supporting hypothesis 2b. In absolute terms, company-owned patents decrease substantially while non-profit-owned ones stagnate. When looking at the names of non-profit organisations one finds (next to public and private research institutes) a lot of

private “societies for technology transfer at university X”. It suggests that some individuals and sponsoring companies had established private transfer intermediaries. They became redundant with the new legislation. This explains the significant decrease of non-profit non-university-filed patents.

The other key explanatory variables show strong influences as well. The later individual researchers started with patenting activities, the more probable it is that their patents are assigned to universities compared to all other groups (except for assignee group 3, where *patexpcoh2* and *patexpcoh3* are insignificant). The difference between the post-2002 and the intermediate group is greater than between the intermediate and the pre-1991 group. An increasing propensity to assign patents to universities over the years could be due to dedicated patent policies at the universities and successful commercialisations. The positive influence of *uni_firstpat* on all groups (significant for individually and company-filed patents) shows that professors at universities with longer experience in patent activities (smaller value of *uni_firstpat*) rely more often on university support. Thus, hypothesis 5 is supported. Because there are more individuals from experienced universities in the database there could be additional effects of attracting scientists interested in commercialisation activities and increasing the number of patenting professors already affiliated by a greater awareness for patent issues.

Regarding the quality of patents our data support hypothesis 4: each of the three quality measures shows a significantly positive influence on company ownership compared to university ownership. Still two of them have a positive influence on non-profit ownership, while they are insignificant for individual ownership and joint ownership of companies and universities.

Most of the further variables in the analysis have explanatory power. Interestingly, professors of universities of technology and of universities of applied sciences have a lower probability to assign their patents to companies. This is contrary to our expectations, because both types of universities are supposed to have close links to industry: in the first case due to the focus on technology and in the second case due to the practical rather than theory orientation. This result needs further investigation which cannot be provided here.

The number of inventors, *invcount*, is significant in all categories: individually-filed patents have fewer inventors than university-filed ones. In contrary, company-filed patents (whether jointly with a university or not) as well as non-profit-organisation-filed ones have more inventors. These ownerships appear usually after collaborations of universities with companies or research institutions. The variable *multprofs* also implies collaboration, but with a different type of researcher and the two variables correlate only moderately. More professors of our database as inventors increase the probability of university ownership in comparison to all other categories. Thus, collaborations with companies seem to consist of one professor, maybe his staff, and company people. When two professors do research jointly, they prefer a patent application in the name of the university.

The patents of younger professors, measured by a later year of PhD (*phdyear*), are more often assigned to companies or non-profit research organisations than to the university. At a first glance, this is kind of contradicting the findings of *patexpcoh1-3*. But 85% of the professors in the databank completed the PhD before our period of observation (responsible for 88% of the patents with information about *phdyear*). Therefore, the result suggests that there was an increasing awareness towards industry contacts and technology transfer for people starting their scientific career in the 1970s and 1980s. We do not find a different influence of *phdyear* on individually-filed or university-filed patents.

Thirty-four of the professors in the database have a PhD from a non-German university (*phdabroad*). They have a lesser propensity to file patents individually. This could be due to the lack of a professors' privilege in the country where they started their scientific career so that they were used to university-owned or company-owned patents. They also file patents less often at non-profit research institutions, maybe because they are not used to a science system with two pillars, the universities and the research institutes.

In order to test hypothesis 3, i.e. to distinguish the effects of the legal reform between professors with different patent experience, interaction variables are introduced and a new model (model 2 in table 4) is estimated. Base category in model 2 is "patents before the legal reform from professors with patent experience prior to 1991". Now one new explanatory variable is *priv_exp2 = (1-law) * patexpcoh2*, i.e. a dummy for patents filed

before the legal reform by individuals with no patent experience prior to 1991. The next interaction variable is: *law_exp12=law * (patexpcoh1 + patexpcoh2)*, i.e. a dummy for all patents after 2002 from experienced professors. We merge the two groups with longer experience in order two avoid too many groups and because the critical point is that all in this group have patenting experience under the professors' privilege. Lastly, *law_expcoh3* is a dummy for the patents of those researchers with first patent experience after the legal reform. The rest of the model is unchanged compared to model 1. As can be seen in table 4, the effect of the law is about twice as strong for those with no patent experience under the old law. Thus, hypothesis 3 is supported.

Model 2	non-profit (2)		univ.+company (3)		companies (4)		Individuals (5)	
variable	coeff.	std.err.	coeff.	std.err.	coeff.	std.err.	coeff.	std.err.
law_exp3	-3.743 ***	(0.525)	-0.588	(0.428)	-3.244 ***	(0.229)	-4.519 ***	(0.430)
law_exp12	-1.845 ***	(0.153)	0.159	(0.286)	-1.660 ***	(0.106)	-2.560 ***	(0.130)
priv_exp2	-0.637 ***	(0.168)	0.327	(0.341)	-0.857 ***	(0.125)	-0.691 ***	(0.130)
uni_firstpat	0.005	(0.004)	0.005	(0.007)	0.016 ***	(0.003)	0.038 ***	(0.004)
fh	-0.157	(0.235)	-0.426	(0.371)	-0.589 ***	(0.164)	-0.339 *	(0.180)
techuni	-0.221	(0.154)	-0.676 ***	(0.241)	-0.269 **	(0.106)	0.218 *	(0.126)
phdyear	0.019 **	(0.008)	0.020 *	(0.012)	0.028 ***	(0.005)	0.003	(0.006)
phdabroad	-1.603 ***	(0.541)	0.527	(0.384)	0.085	(0.216)	-1.350 ***	(0.370)
multprofs	-1.851 ***	(0.257)	-1.467 ***	(0.353)	-1.846 ***	(0.160)	-0.546 ***	(0.171)
invcount	0.380 ***	(0.035)	0.518 ***	(0.047)	0.346 ***	(0.027)	-0.218 ***	(0.037)
epo	1.229 ***	(0.247)	0.590	(0.407)	1.533 ***	(0.180)	0.194	(0.262)
famsize	0.138 ***	(0.025)	0.046	(0.052)	0.206 ***	(0.020)	0.028	(0.024)
numipc	-0.002	(0.020)	-0.009	(0.033)	0.038 ***	(0.014)	0.017	(0.016)
chem	0.996 ***	(0.181)	1.208 ***	(0.316)	1.218 ***	(0.130)	0.190	(0.155)
me	0.286	(0.203)	1.139 ***	(0.337)	0.795 ***	(0.136)	0.071	(0.152)
ee	0.955 ***	(0.221)	1.329 ***	(0.392)	0.988 ***	(0.158)	-0.076	(0.179)
it	0.156	(0.472)	1.716 ***	(0.482)	1.007 ***	(0.243)	-0.567	(0.351)
phys	0.487 **	(0.229)	0.938 **	(0.376)	0.560 ***	(0.158)	0.012	(0.177)
othfield	-0.049	(0.456)	2.204 ***	(0.447)	0.701 ***	(0.256)	-0.143	(0.288)
cons	-49.288 ***	(17.123)	-54.864 **	(25.469)	-88.991 ***	(11.561)	-80.541 ***	(13.804)

Table 4: Model 2; n = 4889, Pseudo R2 = 0.1931, Log likelihood = -5349.6; significance levels ***/**/*: α = 1 / 5 / 10%.

For experienced professors, the lower number of individually filed patents can be seen positive. From the inventor's view, those lacking support in the past have a better infrastructure available now. From the economy's view the probability of a successful commercialisation might be higher for university ownership due to more diverse industry contacts and more time investment. However, a clearly negative effect of the law is on company-owned patents of experienced professors (*law_exp12*). They are reduced, and this indicates existing links are disturbed by the law.

5. Discussion

Several results of our analysis are as expected: first of all, the amount of academic patenting has increased and it has done so since before the legal reform. But it has slowed down lately. Furthermore, the amount of university-owned patents rose sharply, accompanied by an absolute and relative decrease of patents filed by their inventors individually or in the name of companies and research institutes.

However, this is no evidence for the effectiveness of the law to reach the aim of increased technology transfer. To a certain extent, the law just changed assignment patterns, and not necessarily for the better. In particular, lower numbers of company-owned patents are a hint for disturbed science-industry links. When distinguishing between patent-experienced and inexperienced professors (hypothesis 3), we observed a decreased probability of company-owned patents after 2002 for both groups. The effect is twice as strong for inexperienced professors, but it is still not negligible for experienced ones. With our data we cannot investigate whether the companies license the technologies from the universities now. The companies would face higher administrative effort, more costs, and they would face the risk that the university finds additional licensees. Avoiding this by means of an exclusive licence should further increase the price. Therefore, one can expect some industrial partners to refrain from licensing the results of collaborative research. Anticipating this, some companies will reduce collaborative research. Together with the evidence that company-owned patents are correlated with higher quality (according to our quality measures) a lower number in this group of ownership gives evidence for decreased technology transfer.

Regarding patents owned jointly by a university and a company, we do not find great differences toward university-owned ones. The collaboration variables *multprof* and *invcount* are significant; then *techuni*, *phdyear*, and the dummies for the fields of research. Patents from medical, pharmaceutical and biological departments have less often combined ownership than from all other fields, whereas there is no significant difference between almost all other fields. In summary, joint applications do not differ much from university applications, but they occur preferably at engineering, IT,

chemical, and physics departments. The same fields of research increase mere company ownership.

As discussed in section three, we have a certain selection bias in our data: We are lacking those professors who have never filed a patent in the university's name. Therefore we may have disproportional many individuals in our database who benefit from the law or have a positive opinion of it. This may partly explain why in our dataset the overall number of university-invented patents does not decrease in contrary to what Schmoch (2007) found. A second factor possibly explaining the higher numbers is that we excluded all individuals who retired until two years after the legal reform, while young scientists becoming professors and starting patent activities were included during the greatest part of the period (those becoming professor prior to 2000 and in individual cases even later, if they had already patent activity during their PhD or post-doc time).

6. Conclusions

The present paper analysed the effects of the abolition of the professors' privilege in Germany in 2002. By means of a multinomial logit model we identified various factors explaining the assignment patterns of university-invented patents. The legal reform clearly produced a shift towards university assignment. Other variables have additional explanatory power. Experience of the technology transfer office, measured by the year of the university's first patent application, enhances the likelihood of university ownership and suggests a path-dependent development of successful transfer activities. A higher quality of the patents correlates with company ownership, but with our data we are not able to reveal the direction of causality. Fields of research differ in their in industry orientation.

When distinguishing between patent-experienced and inexperienced professors, the effect of the law is stronger for the second group. Nevertheless, the reduced number of company-owned patents from patent-experienced professors suggests a negative effect of the law on existing science-industry links. This contradicts the intended aim of the law: to

enhance technology transfer. A second indication that this aim was not reached is that there is no systematic change in the trend of all university patents after 2002.

From these findings the question arises: what rationale is there for mandatory disclosure of inventions? We have evidence that professors sought university support prior to the abolition of the professors' privilege. And we know that the experience of universities with patent activities enhances the probability of university ownership. Thus, a voluntary regulation could be useful to guarantee low patenting barriers but at the same time ensure that existing connections to industry are not affected. Only the hope for revenues legitimates the mandatory regulation, but this could be short-sighted: patent earnings are highly skewed and the experience shows that most technology transfer offices in the U.S. and Great Britain run at loss (Heher, 2006), while the overall positive effect of patents appears on aggregated levels of the economy (Von Ledebur, 2008).

Appendix

Model A1:

Model A1	non-profit (2)		univer.+companies (3)		companies (4)		individuals (5)	
variable	coeff.	std.err.	coeff.	std.err.	coeff.	std.err.	coeff.	std.err.
law2002	-1.344 ***	(0.344)	0.089	(0.413)	-0.849 ***	(0.187)	-1.355 ***	(0.218)
law2003	-1.290 ***	(0.263)	-0.386	(0.404)	-1.340 ***	(0.189)	-2.140 ***	(0.259)
law2004	-1.869 ***	(0.394)	-0.441	(0.437)	-1.261 ***	(0.179)	-2.269 ***	(0.264)
law2005	-1.486 ***	(0.367)	-0.253	(0.423)	-1.256 ***	(0.243)	-2.652 ***	(0.347)
law2006	-1.717 ***	(0.326)	0.635	(0.483)	-1.670 ***	(0.215)	-2.884 ***	(0.315)
uni_firstpat	0.006	(0.010)	0.002	(0.012)	0.017 ***	(0.006)	0.039 ***	(0.008)
patexpcoh2	-0.446 *	(0.241)	0.271	(0.400)	-0.529 ***	(0.189)	-0.374 *	(0.193)
patexpcoh3	-2.153 ***	(0.572)	-0.537	(0.489)	-1.871 ***	(0.319)	-1.966 ***	(0.439)
fh	-0.198	(0.433)	-0.310	(0.490)	-0.615 **	(0.274)	-0.337	(0.326)
techuni	-0.197	(0.316)	-0.745 **	(0.376)	-0.241	(0.198)	0.242	(0.231)
phdyear	0.024	(0.016)	0.011	(0.020)	0.033 ***	(0.010)	0.006	(0.012)
phdabroad	-1.577 ***	(0.515)	0.387	(0.573)	0.088	(0.418)	-1.357 **	(0.596)
multprofs	-1.851 ***	(0.354)	-1.529 ***	(0.521)	-1.861 ***	(0.221)	-0.552 **	(0.243)
invcount	0.383 ***	(0.053)	0.531 ***	(0.063)	0.351 ***	(0.045)	-0.208 ***	(0.063)
epo	1.322 ***	(0.367)	0.534	(0.540)	1.633 ***	(0.253)	0.343	(0.331)
famsize	0.116 ***	(0.041)	0.070	(0.058)	0.182 ***	(0.029)	-0.001	(0.041)
numipc	-0.003	(0.025)	0.003	(0.031)	0.036 **	(0.016)	0.014	(0.019)
chem	0.979 ***	(0.371)	1.241 **	(0.603)	1.206 ***	(0.267)	0.206	(0.296)
me	0.281	(0.352)	1.213 **	(0.554)	0.784 ***	(0.258)	0.083	(0.293)
ee	0.923 **	(0.390)	1.421 **	(0.580)	0.971 ***	(0.279)	-0.069	(0.313)
it	0.141	(0.765)	1.738 **	(0.685)	0.986 *	(0.447)	-0.575	(0.535)
phys	0.485	(0.397)	0.988 *	(0.541)	0.563 *	(0.321)	0.019	(0.308)
oth	-0.062	(0.839)	2.204 ***	(0.632)	0.700	(0.435)	-0.162	(0.776)
cons	-61.786	(39.715)	-32.101	(45.617)	-100.022 ***	(23.006)	-87.110 ***	(26.280)

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