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University-owned patents in West and East Germany and the abolition of the professors' privilege¹

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Abstract:

This paper analyses the development of universities' patent applications in Germany before and after the abolition of the 'professors' privilege' in 2002. By means of a database with all patent applications of German universities with professors among the inventors (1990-2006), systematic changes in the trend are investigated. There are contrasts in the patenting patterns of universities with or without long patenting experience. A structural break at the point of the new legislation is found only for universities without patent activities in the past. This indicates the importance of collecting patenting experience and that the amount of patents is path-dependent.

Keywords: university patenting, Germany, technology transfer, professors' privilege.

JEL Classifications: O34, O38, L31

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1 Introduction

During the 1990s, in their search for instruments to enhance the industrial use of academic inventions, German policy makers turned to the observable rise in patenting activities of US universities over the past 20 years. The rise was attributed to the Bayh-Dole-Act, a law assigning intellectual property rights (IPR) to the employing university. In Germany, university researchers had retained the IPR of their inventions since the first half of the 20th century, which allowed them to decide freely what to do with these inventions (including the right to do nothing). Similar regulations were valid in other European countries. Nevertheless, one can observe patent applications from universities during the 1980s and 1990s.

This “professors’ privilege” was abolished in 2002. Accordingly, since then the universities have the right to file patents on their employees’ inventions. In case the university does not file a patent during a certain time span after the disclosure of the invention, the IPR goes back to the inventor. The law assigns 30% of the gross revenues of a patent to the inventor. This means that the university pays for all costs related to the patent application. The law increases incentives for the scientists to disclose inventions, because there is no financial risk but only a chance of additional income when only participating in the gross revenues and not in the patent costs. In comparison with the old legislation, two groups of inventing professors are worse off: those filing high-value patents in their own name and those used to industry contracts where funding is provided in exchange for IPR. In the latter case now the transaction costs are increased due to a third party (university) involved in the transfer process.

One can observe a significant increase in university-owned patents since 2002 (cf. Schmoch, 2007). But regarding earlier university-owned patents, the legislation can not be completely responsible for the figures. A closer look shows that the majority of university-owned patents during the 1990s were filed by East German universities. They did not have a professors’ privilege during socialist times. Thus the universities had already experience with filing patents and the necessary infrastructure existed. As known from previous literature about university patenting in the USA, the influence of transfer intermediaries is significant (cf. section 2). Because the transfer infrastructure in Germany was extremely widened in parallel to the legal reform, the individual contributions of legislation and infrastructure to the increase in university patenting can not be seen directly. To the author’s knowledge, there are up to now no studies disentangling these effects and the paper at hand wants to perform this task partly.

Additionally, the paper investigates whether the old legislation was a barrier for patenting for the professors, because the main rationale behind the legal reform was to enhance technology transfer. For this analysis of first-time patenting professors, not only university-owned patents play a role but also university-invented patents owned by companies, research institutes, or individuals. Recent literature was able to show that the difference in the perceived amount of university patenting between countries is often just a question of assignment. Prior

to the legal changes, patents with university involvement in Europe have been assigned to companies to a great extent (see e.g. Verspagen, 2006; Geuna and Nesta, 2006). For a summary judgement as to whether the 2002 legislation was successful the effects on universities, on inventors, on collaborating companies as well as on the overall amount of academic patenting have to be investigated. As a start of this task, this paper mainly restricts to an analysis of effects on university-owned patents as one part of these effects.

The remainder of the paper is structured as follows. It starts with a short discussion of the universities' incentives to patent and an overview of the state-of-the-art literature. Then I formulate hypotheses on the development of university patenting regarding the new law on employee inventions in section three. The description of the newly created database follows. Section five presents the results. They are discussed in the last section, which also concludes.

2 Factors for university-owned patents

The legislation does not set direct incentives for the universities which have to bear the financial risk of the patent and licence process. However, the government helped to establish transfer intermediaries (the so-called *Patentverwertungsagenturen*, PVA) by providing initial funding. Subsequently, continued public funding for transfer offices was limited to those with promising marketing strategies, which were selected in a competitive process (cf. von Ledebur, 2009). In some regions, these intermediaries are responsible for the whole process from checking an invention for patentability to bargaining licence contracts. In other regions, they take care of the commercialization process only. As almost all universities have now some kind of technology transfer intermediary, the additional contribution of the PVAs may be limited, even though they may play a role in the commercialization process of patents.

Direct incentives for universities to engage in patenting are therefore limited and theoretically, they could always give back the IPR to the inventors. Those universities who are able to build up "patent reputation" may benefit from increased industry attention, but most likely only a limited number of (large) universities will be able to generate the necessary numbers of patents. The University of Technology Dresden is an example for this strategy (see section 3.1). Policy expects universities increasingly to have visible results of tax-paid research by producing patents. There is a development from the university as a research and teaching institution towards the entrepreneurial university, which engages in several forms of technology transfer (cf. Etzkowitz and Leydesdorff, 1997). As often, the US started earlier with this institutional change and serve as an example for European countries. The comparison with the US may be wrong due to different legislative frameworks and a selective comparison with the best universities only, but it exerts some moral pressure. Additional, financial incentives must not be neglected: in spite of evidence that only few patents will cover their costs and even less will generate substantial income (see e.g. Scherer and Harhoff, 2000; Heher,

2006), many universities seem to hope to find the “nugget”. Patents can also be used as deposits for spin-offs from universities (cf. Fritsch et al., 2007, chapter 6). Thus, both reputation and financial objectives may be responsible for the universities’ patenting activities.

Previous empirical literature found that support infrastructure for university inventors, funding regimes, labour regulations, state control, the existence of medical schools, and incentive schemes play important roles for patent activities and assignment patterns (e.g. Thursby et al. 2007). 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. At present, the technology transfer infrastructure in Europe is less developed than in the US, and personal contacts exist mostly through the professors themselves.

Huelsbeck and Menno (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 path dependency.

In summary, the university’s experience in patenting activities plays a crucial role for the amount of patents filed. The experience is closely related to a well-functioning infrastructure, because the organisational infrastructure is a precondition for patent applications from universities. If no employee of the university is responsible for patenting, the university can not be applicant of a patent. It is not necessary to have an independent TTO for filing patents. Lower level organisations as an employee of some other university service institution responsible for all patent activities can be supportive for inventors as well and represent a kind of patent infrastructure. In the following, both expressions (experience and infrastructure) will be used to describe the support of universities in patent activities. In the empirical part the year of the first patent filed will be taken as a proxy for them.

The USA have more than 25 years of experience with a law assigning IPR of academic inventions to the university. A substantial literature exists on the effects

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

of the Bayh-Dole-Act. There is evidence that the law is at most partly responsible for the upsurge in university patenting (cf. Mowery et al., 2001).

Based on these prior findings, the main purpose of this paper is to distinguish two effects on the number of university-owned patent applications: IPR law on the one hand and patenting experience on the other. It will be discussed then, if both are necessary for university-owned patents. In this way, the paper hopes to contribute to an improved understanding of the effects of Bayh-Dole-like legislation in an institutional context. The practical relevance of this topic is shown by first studies finding that attempts to professionalize the commercialisation of university technologies by a mandatory regulation may actually have adverse effects on technology transfer: in Denmark, the same legal reform as in Germany was introduced in 2000. Valentin and Jensen (2007) analyse its effects on science-industry collaborative research in the biotech sector. University-owned biotech patents do not fully compensate for the decrease in company-owned patents, i.e. the overall amount of patent applications with academic background decreased.

Also, Lach and Schankerman (2008) as well as Thursby and Thursby (2005) observe that private universities in the US are more successful in retaining IPR over their scientists' inventions than public ones. Due to a longer history of self-funding they have developed closer links to industry, and also well-established intermediary offices for science-industry relationships. European universities have even less control than US public universities over their employees after hiring them. Professors in Germany are usually civil servants with tenured contracts. This means that universities cannot enforce the disclosure and professors can oppose unpopular regulations. But the universities can set incentives to disclose inventions: even though there is little to no possibility in adjusting salaries, they still can legitimate themselves by being helpful intermediaries. A regulation with incentives (attractive patenting support) rather than duties (mandatory disclosure of inventions to the university) could be superior. A hint in this direction will be given here by analysing whether the legal change was able to enhance the overall propensity to engage in patent activities.

To the author's knowledge, the studies of Huelsbeck and Menno, and of Valentin and Jensen, are the only ones that have studied changes in patenting and research collaboration behaviour in Europe after universities acquired ownership of their professors' inventions. Even though for an overall evaluation of the legal change an analysis of all academic patents has to be done, it is necessary to know the effects on the universities themselves and which factors contribute to what extent to the increasing number of university-owned patents. In the remainder of this paper, I will start to perform this task.²

² In a broader context, it is important to note that patents and licenses are only one of many channels of technology transfer from universities to the private sectors, with alternative channels (publications and conferences, labour mobility, informal contacts, consulting etc) probably being more important than patents in many industries. Studying technology transfer from the MIT, Agrawal and Henderson (2002, p. 45) conclude "that patenting may play a relatively small role in the transfer of knowledge out of the university". Survey evidence from industrial R&D managers

3 Hypotheses and Method

3.1 IPR ownership legislation, experience, and path dependency

According to the available evidence on technology transfer offices their commercialisation experience plays an important role for the patent activities of professors. The effects of the new law are more difficult to figure out. One rationale for the legal change was the aim to decrease patenting barriers. To file a patent by oneself is a rather time-consuming and difficult task, because different abilities are needed compared to doing research. Additionally, it is expensive, at least when the protection shall encompass several countries. This consideration ignores the fact, that the inventors may give the IPR to companies which in return provide funding for research projects. Even if the new legislation facilitates the patent process for inventors without industry contact, it could impede the process for those having established links to companies (as the first evidence of Valentin and Jensen, 2007 shows). The ambiguous effects of a mandatory regulation are contrasted by an intuitively positive effect of the existence of patent support infrastructure: no other existing structures are touched while there is a possibility to reach further inventors.

Hypothesis 1: Universities' experience in patent activities enhances the amount of university patenting stronger than a Bayh-Dole-like legislation on academic inventions.

To disentangle the effects of IPR law and commercialisation experience, a n institutional particularity of Germany is useful: before Germany's reunification in 1990, academic inventions made in socialist East Germany were treated differently from those made in the West. No professors' privilege existed in East Germany, but a Bayh-Dole-like legislation had been in place since the 1970s, and universities had to file patents. As a consequence, one finds about 6000 patent applications of East German universities prior to 1991 (with priority German Democratic Republic).³ In contrary, there exist only about 300 patent applications of West German universities in the same time period. Thus, most East German universities had an organisational unit responsible for patent applications. However, we do not know the quality of these patents and whether they were licensed to industry or otherwise used. Only 100 of the 6000 patent applications were also filed in West Germany. But the point is that a regulation what to do with disclosed inventions existed and there was someone responsible for filing patents. After reunification these organisations were often reorganized as technology transfer consulting offices (as own entities or affiliated to another service institution of the university),

(Cohen et al., 2002) or German academics (Schmoch, 1999) comes to similar conclusions. Nevertheless we will again focus on patents in our study, because we are analysing the effects of a legal change on the patent behaviour of universities.

³ The search for patents with applicants *univ** and *hochsch** was conducted in the *depatisnet* database.

and some were even closed down. The universities of Jena and Dresden are remarkable exemptions from this development, resulting in an appreciable number of patents filed by these two universities throughout the 1990s.⁴ Dresden and Jena accounted on average for about 50% of all East German university patent applications in the 1990s.⁵ The case of Dresden is special due to the university's chancellor Post, who strongly supported patent activities as a mechanism of proving the high level (quantity and quality) of research (cf. Fritsch et al., 2007). This led to the high patent application numbers since 1994, which have stayed on this high level ever since (ca. 20 patent applications per year). However, the relative share of Dresden's patent applications has steadily decreased since the initial peak of 1995, because other East German universities followed Dresden's development.

Similarly to Dresden and Jena in East Germany, a small number of universities in the western part of Germany have transfer institutions with long experience, the medical school of the University of Freiburg and the engineering faculty of the University of Stuttgart are cases in point. Both are located in Baden-Württemberg, whose government earlier than others in Germany realised the importance of university inventions. They account on average for about 25% of all West German university patent applications throughout the 1990s. This is a first hint that indeed the infrastructure plays a greater role than the legislation.

On average, East German universities had more experience in supporting inventors with patent applications during the 1990s. In addition, more universities bore the expenses, while existing transfer offices in West Germany often limited themselves to consulting. This financial aspect may be important given the costs of patenting and the uncertainty of success. If now the commercialisation infrastructure is given, one can see the pure effect of the legal reform. Developing hypothesis 1 further means that we should see in East Germany the pure effect of the legal reform while in West Germany there are combined effects of law and infrastructure establishment.

Hypothesis 1a: Following the legal reform of 2002, there is a systematic change in the number of patent applications made by West German universities, but not in the number of patent applications made by East German universities (adjusted to the number of professors).

Of course, the distinction between East and West Germany is just a rough proxy for a better infrastructure. There have been some West German universities with a TTO and at the same time East German universities without one. By means of a selection of patents owned by universities I will repeat the test with another proxy. The patents used to this end have professors among the inventors for whom we have affiliation information and who have been active before and after 2002. By

⁴ Huelsbeck and Menno (2007) show that East German universities generally had a higher share of all university patents before, but not after the legal change of 2002.

⁵ The figures refer to the databases of this paper; see section 4.

excluding professors retired before 2002 we can analyse changes in patenting behaviour due to the law. Professors' patent applications are included only when they are affiliated to a university with patent experience before German reunification. Thus we have a sharp measure of patent experience and can extract the influence of the legal reform. There are two caveats in the analysis: first, I can not track employment history and therefore some noise exists in the data for professors changing affiliation. Second, the number of patents which can be included in the analysis is smaller.

Hypothesis 1b: The number of university-owned patents of professors affiliated to universities with long patent experience shows no systematic change at the point of the legal change.

Experience and legislation are not the only factors influencing patent application numbers. There may be an overall trend towards patentable technologies (cf. Geuna and Nesta, 2006). I account for that by not assuming a constant number of applications, but searching for a structural break in an existing trend.

Whenever the university has been engaged in patenting for a longer time and the TTO was in operation already before the professors' privilege was abolished, patent activities must have been based on a dedicated commercialization policy.⁶ Over the time, this should lead to greater awareness of patenting issues, and positive experiences made with the technology transfer office. This in turn enhances future patenting propensities if communicated on campus, i.e. more professors at this university engage in patent activities. Reputation and patent activities are two self-enhancing factors can be expected to increase the number of patent active professors at a university and they are evidence for path-dependency in patenting activities. The causal relationship is probably from higher reputation leading to an earlier start with patenting activities. At the same time, it is theoretically possible that professors interested in patenting are more attracted by universities with high reputation and with an experienced TTO. This might influence their decision when been offered a chair at another university. However, regarding limited labour mobility of professors this effect should be negligible. In our context there is no special reputation variable, but experience in technology transfer is taken as a proxy. Even if experienced TTOs are more selective about invention disclosures, I expect the former effects to overbalance this.

Hypothesis 2: Universities with patenting experience before 2002 have larger shares of patent active professors today.

⁶ According to Friedman and Silbermann (2003) a focused mission on licensing makes TTOs successful. Additionally, they find like Thursby et al. (2001) a positive influence of TTO size on licensing. Patents and licences are not the same, but related transfer activities, therefore one can assume the same for patents.

3.2 First-time inventors

Mowery et al. (2001) did not find a sudden change in university patenting behaviour in the US after the Bayh-Dole-Act was introduced. Here, the change in patenting behaviour for Germany on an individual level is of interest: if the new legislation reduced patenting barriers more professors would be expected to take up patenting activities. Accordingly, I will first investigate whether the annual number of German professors filing their first patent shows a steady trend between 1991 and 2006 or whether it has a structural break. A steady increase would hint at increasing technological opportunities. Different kinds of IPR ownership of the respective patents are neglected here, because I want to find out if there existed overall barriers. First there is the question how many professors filed their first patent before the period of observation. For the others one expects that the number of first-time patenting professors stayed constant during the 1990s and increased afterwards, if the old legislation was a severe barrier for patent activities of professors.

Hypothesis 3: The trend of first-time patenting inventors increases since 2002 and has been steady before.

In order to test hypotheses 1 and 3 tests on structural breaks are applied, i.e. the Chow test and the CUSUM test. Hypothesis 2 can be tested by a comparison of means.

4 Data

4.1 The databases

German professors frequently make use of their title in patent applications. Following earlier work on academic inventions in Germany (Becher et al. 1996, Abramson et al., 1997), the initial step in identifying patents of German professors was to search for patent applications made by German universities (including *Fachhochschulen*) that had the title "prof" in the inventor field. In this way PhD students were excluded who patented independently of their advisors, as well as post-docs and non-professor university staff, which corresponds to other work on European academic inventors (e.g., Lissoni et al., 2007). The data encompass all years since reunification for which we have data. Due to the time lag between patent application and publication (18 months) this results in data from 1990 to 2006. The search was done in Depatisnet, the online patent database of the German Patent Office (DPMA). The focus is on patents filed with a German priority because universities usually file a patent first in the home country. For every patent then information about the location (East/West Germany) and the type of university (*Universitäten /Fachhochschulen*) of the assignee was added.

Based on the initial database (in the following referred to as the "university database"), I searched all identified professors individually to find all their patent

applications with German or European priority independent of whether or not these were assigned to universities (and irrespective of professor titles). In particular, this procedure allows identifying academic patenting activities prior to 2002. Internet queries gave evidence whether the professors were employed in public research during most of the time period under investigation.⁷ This step was necessary to sort out professors who retired before the new law came into effect. Additionally, individuals who became professors recently and worked in the private sector for all of the 1990s were excluded. For some individuals I hardly found any information in the internet. These were also excluded because one cannot assure whether they have been working in academia or in industry (like many professors at universities of applied sciences) in the past.⁸ Finally, a check on homonyms on the basis of comparing residences, assignees, and technology classes of patents was done. 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. To each patent in the database I added the year of the first patent application of the university, where the inventor was employed in 2006 (last year of available patent data). This is taken as a proxy of patent experience of the university. The development of a support infrastructure for patenting has often been gradual: when the awareness for patenting issues appeared usually some service institution which consulted inventors was established. The tasks were then broadened by the time and if the university was really interested in the topic, some budget was made available. A formal founding of a TTO could take place later when the activities were formalized (e.g. Universität Hohenheim) or could be founded first in expectation of later patent activity (e.g. Universität Marburg). Because the years of TTO establishment can be found in the internet only for a small number of universities, the year of the first patent application seems to be the best proxy for patent experience.

For the patent applications thus identified, a dummy variable was added taking the value one for patents filed by a university or public research organization (possibly jointly with other assignees). All other types of assignees received the value zero. These data form the second database (in the following the "professor database"), which accordingly contains all patent activities of German professors who were active in public research both before and after the change in law and who are inventors named on at least one university-owned patent in the observed period. To validate the representativeness of the data, in companion work patent searches for the entire population of professors at six selected universities were conducted. This research gives evidence that we cover only about 60% of public universities' professors active before and after 2002 and about 70% of their patents. There is a selection bias towards those professors benefiting from the transfer policies: we have professors who refrained from patenting in the past only due to lack of

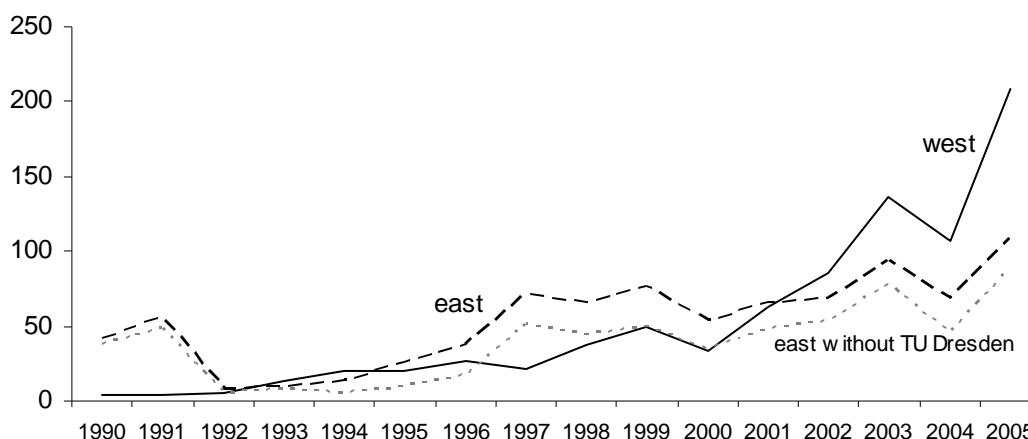
⁷ For the professors filing university-owned patents before as well as after 2002 we did no further analysis. For the rest, if we did not find a CV, we looked for other information like newspaper articles or checked for a constant amount of publications over the years (if available).

⁸ It is not uncommon for industry R&D staff to have the title of a (honorary) professor, which is often because of teaching activities besides their primary job at a commercial firm.

support and who now file patents in the name of the university. In contrast, professors who organized patent activities prior to 2002 on their own and oppose the new law by circumventing the mandatory rule are missing in the database. Such scientists can appear at all universities and for the analysis at hand a bias arises only insofar as universities with less experience in patent activity may have more employees opposing the law. Overall, both databases have limitations, but the double analysis validates the results.

4.2 Descriptive statistics

The university database covers the time period from 1990 to the first half of 2006, i.e. all years after reunification for which data was already available at the date of the search. For yearly analyses the data from 1991 to 2005 can be used, which results in 1652 patent applications in the university database. Of these, 777 were made prior to the legal changes in 2002. This shows that the professor's privilege notwithstanding, German universities held substantial ownership in the inventions made by their professors even then.⁹ Universities in East and West Germany each filed about half of the total number of patents, but the East German universities account for a larger share of the patents filed in the first part of the period, while the West German ones lead after 2002. This is in line with the findings of Huelsbeck and Menno (2007), who have a slightly different database (including post-docs' and PhD-students' patent applications). The distribution of applications made by individual universities is highly skewed, with the TU Dresden having filed 257 patents (the University of Jena ranks second with 125), while 30 universities have filed just one or two patents.



⁹ In order to check if that sample is representative for all patents filed by universities I shortly analysed those university-owned patents where no "prof" title appears in the inventor field of the database. The amount of patents is nearly the same and the two dominating IPC classes are the same in both groups. Regarding the subclasses there are only slight shifts in the frequency of individual classes: 21 out of 26 subclasses with more than 50 patent applications (main and secondary technical field) are the same. The University of Technology Dresden and the University of Jena are in both databases clearly the universities with the most applications. Therefore one can assume the constraint on patents with professor title in the inventor field to be reasonable.

Figure 1: Patent applications of German universities with at least one professor title appearing in the inventor field of the patent document; comparison of location in the eastern and western part of Germany. The East German numbers from 1990 are only those patents with priority of the Federal Republic of Germany.

There are pronounced differences in the number of the universities' patent applications in the eastern and western parts of Germany. In the east, one observes a sharp drop in patent applications following reunification. The reorganisation of the science and education system inhibited to focus on high quality research. However, the eastern universities restart patenting before an increase in the patenting rates of western universities can be observed. Around 2002, a view on the graph shows a rather steady increase in the east, while the western universities filed four times as many patents in 2003 than in 2000 (Figure 1).

Many patents have a public research institute as second assignee, which indicates they resulted from research cooperation with such institutes. Similarly, there is evidence for research collaboration with companies. Thursby et al. (2005) found that 4% of U.S. university-invented patents were assigned both to a university and a commercial firm. The same happens more often in Germany, with co-assignments accounting for 6.3% (before 2002) and 7.0% (after 2002) of the applications in our sample. Additionally, we find the combination of university and inventor as assignees (5.0% and 1.0% respectively) as well as some rare cases with university, company and inventor (5 patent applications, all before 2002). Co-assigned patent applications count as university-patents in our analysis, because the inventor sought university support, which the university was able to give.

The professor database contains 1300 professors affiliated to a German university who applied for at least one patent through a German university in the period from 1990 to 2006. After sorting out those not useful for our analysis (as explained in the preceding subsection) and those with missing employing information, 986 individuals could be included in the empirical analysis. Each of these professors worked at a German university at least two years before and after the change in legislation.

In total, we have 5970 patent applications where there is additional information about the year the university employing the inventor filed a patent for the first time.¹⁰ About one fourth of the patents overlap with the university database. Dividing the patents into two groups according to whether the university filed the first patent before or after January 1, 1991 (beginning of the period of observation) results in 3277 patents in the first and 2693 patents in the second group. Almost the half of the patents is assigned to a university or another non-profit research institution.

¹⁰ There are 6% of the patents included twice or three times. In these cases, more than one professor of the database is among the inventors and for each one the information about the university's patent experience is included.

5 Tests of hypotheses

5.1 IPR ownership legislation, experience, and path dependency

The data show rather complex patterns for university-owned patents. After 2002, the number of universities with at least one patent application increased from 69 to 125. As we have seen in figure 1 the universities in East Germany restarted a few years after the reunification with patent activities. In West Germany, the universities started later but faster to expand patent application numbers. In order to test hypothesis 1a postulating different dynamics in East and West after 2002, the university-level patent application data was split into semi-annual observations and the numbers were set in relation to the professors in patent relevant fields (natural sciences, life sciences, IT, and engineering; cf. figure 2).¹¹ The extended Chow test for structural breaks (F-statistics for every point in time) results in a peak in the second half of 1996 for the universities in East Germany. This indicates a structural break at that time. The reason behind is possibly the sharply decreasing patent applications in the first years after the reunification followed by some years of little patent activity at all. Therefore, a regression on the first years may have a rather negative trend, while later there is again a clear positive trend, which results in a structural break.

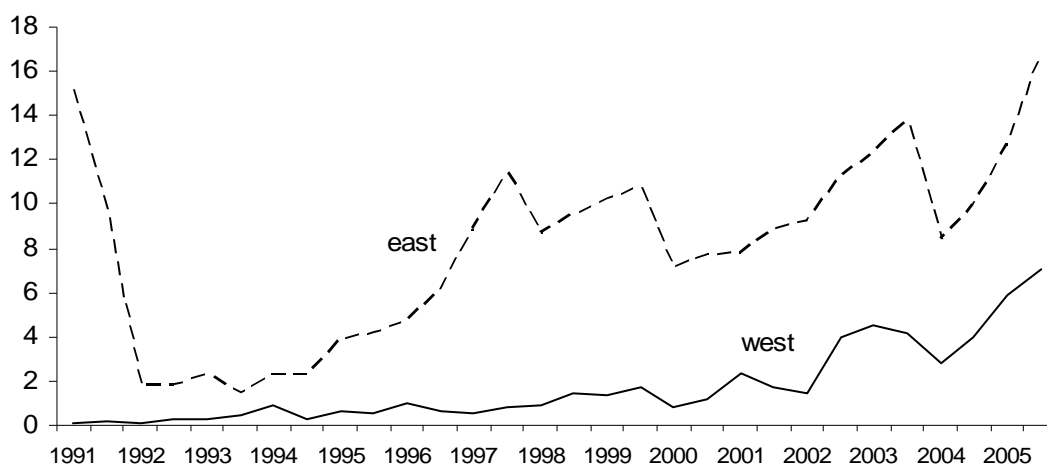


Figure 2: Patents per thousand professors in patent relevant fields, semi-annual data; university database.

Strikingly, there is a structural break in West Germany exactly in the first half of 2002, the date of the legal change. There is one caveat: the assumption of constant variances of the error terms does not hold for the West German data. Therefore the F-statistics have overall high values and one cannot rely on the significance test. The CUSUM test with OLS shows a significant break at the same

¹¹ Source: Statistisches Bundesamt Deutschland, Hochschulstatistik, own calculations.

point in time, but also assumes constant variances. In order to check the significance of the assumed break, I make a linear regression with dummy interaction variables for slope and intercept. The dummy takes the value one for all half-years from 2002 (first half) on and the estimated coefficients are highly significant and the slope increases strongly from 2002 on. In summary, hypothesis 1a is supported for East and West Germany by the data. Of course, there may be later break points which we cannot make out now, but the data do not suggest this.

A similar test with a better proxy for patent experience strengthens the infrastructure-and-experience hypothesis: In the professor database individual information about the inventing professor was linked with the patent data: the year of the first patent filed by the university where the inventor is employed. When taking all patents of professors employed at universities with patent experience before the period of observation there is no increase due to new universities appearing in this group. By this, the effect of the legal change can be separated from the effects of new transfer intermediaries. The other ("inexperienced") group contains all universities starting to patent during our period of observation. Here the effects of the infrastructure and the legislation can not be separated. Again, a test on structural breaks is conducted. In the experienced group one finds a break in the first half of 1997, similar to the result above. In the inexperienced group there is a break clearly in the first half of 2002. Universities starting with patent activities after 2002 as well as an increase in post-2002 applications of those which started patenting in the 1990s are responsible for a sudden upsurge. Thus, hypothesis 1b is supported. The similar results of the two different tests support the overall hypothesis 1.

As a robustness check for hypotheses 1a and 1b, I analysed differences between *Universitäten* (research universities, including universities of technology) and *Fachhochschulen* ("universities of applied sciences"), which are more teaching oriented. This translates into smaller numbers of staff scientists and lower values for traditional measures of research output such as publication and citation counts. According to a large literature, research performance and technology transfer activities tend to be directly related (cf. Friedman and Silberman, 2003; O'Shea et al., 2005). Table 1 shows the different amount of increase depending on the kind of university.

While many patent-owning *Universitäten* began their patenting activities before the 2002 change in law, *Fachhochschulen*, particularly those located in West Germany, often refrained from patenting until the new law was enacted. Regarding the whole population of German universities, 69 of about 100 existing public *Universitäten* filed patents in the entire period under investigation, and roughly half of all before the new law. The number of *Fachhochschulen* in Germany is more difficult to count and varied over the time of observation due to mergers and closures (mostly in East Germany). There are about 200 public ones; thus only a quarter of them has filed a patent in the period observed.

Region:	East		West	
Type of University (# in database):	Universitäten (15)	Fachhochschulen (18)	Universitäten (54)	Fachhochschulen (38)
Before February 7, 2002	13	10	35	11
After February 6, 2002	15	15	52	34

Table 1: Number of universities in east and west active in patenting before and after the change in law, subdivided into the kind of university; out of the population of all German universities which have filed at least one patent during 1990 and 2006.¹² *Universitäten* include universities of technology.

The number of one-time patenting universities is rather low with 15%, while 40% have filed ten or more patents. Some rather large universities started to patent past 2002 and filed more than 10 patents since, e.g. the Universities of Marburg, Würzburg, Frankfurt, Bonn and the Universities of Technology in Darmstadt and Kaiserslautern. This is an indication for a profoundly changed awareness towards patenting.

For the tests for a structural break on the level of the kinds of universities (and distinguishing between East and West Germany) the patent applications were again set in relation to the number of professors in patent relevant fields. There are no substantial structural differences between *Fachhochschulen* and *Universitäten*. In East Germany, the former exhibit no break at all (F-statistics as well as OLS-CUSUM test) and the latter have a break in 1996 (significant with the F-statistics and OLS-CUSUM test at 1%). In West Germany, a break is found in the first half of 2002 for both types. Again, the significance cannot be proved because of increasing error variances. The check with a linear regression results in significant estimation coefficients for the interaction variables (slope and intercept; significant at 10% for *Fachhochschulen* and at 1% for *Universitäten*). There seems to be a greater difference between West and East than between *Fachhochschulen* and *Universitäten*.

Figure 3 shows the patent numbers of the four categories adjusted to the number of professors in patent relevant fields (natural sciences, life sciences, IT, and engineering). The number of professors for 2005 and 1991 are estimations. In both parts of Germany, *Fachhochschulen* have a significantly lower patent propensity than *Universitäten*. This is to be expected given their teaching-oriented mission and the smaller numbers of research staffs supporting professors. However, *Fachhochschulen* in East Germany have similar values to *Universitäten* in West

¹² The patents of those which were patent active before a merger were added to the university they merged with (e.g. Hochschule für Verkehrswesen became part of TU Dresden and TFH Leuna-Merseburg became part of the University of Halle). The medical school of Humboldt University of Berlin ("Charité") was counted as an own university because its patent applications are always marked separately and it merged with the medical school of the Free University of Berlin some years ago.

Germany (t-test shows no difference). This analysis suits well to those above and strengthens the evidence that universities' experience in patenting weakens the influence of the law on IPR ownership.

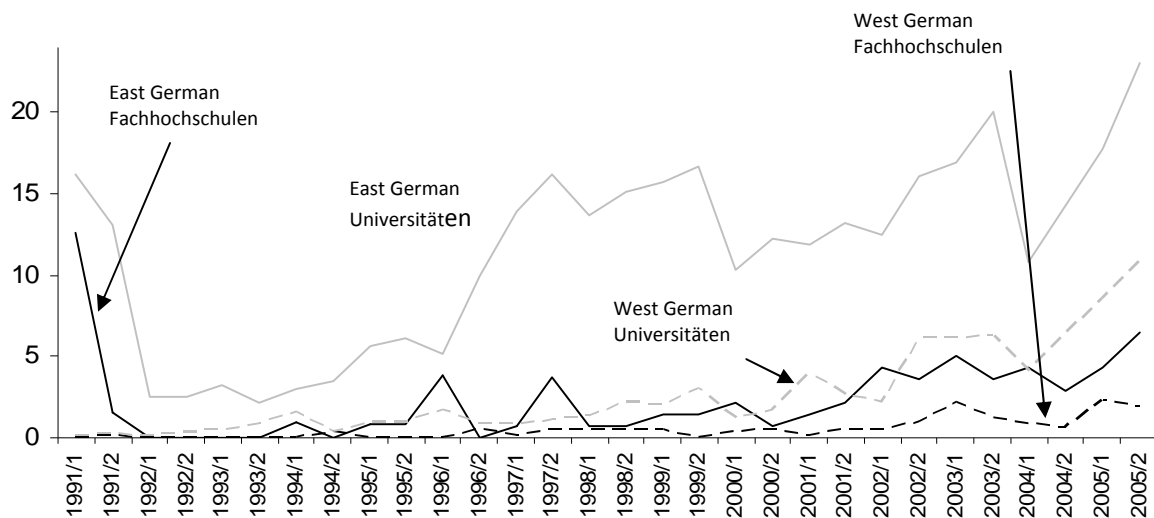


Figure 3: Semi-annual patent application numbers of *Fachhochschulen* (black lines) and *Universitäten* (grey lines) in East (solid lines) and West (dashed lines) Germany.

Source: *Statistisches Bundesamt Deutschland*, own calculations.

Hypothesis 2 postulated that patenting experienced universities employ a greater number of patent active professors. "Patent active" means engaging in patenting activities, irrespectively of the assignee of the patents. The comparison of means shows that the average number of patent active professors (in 2006, included are the individuals from our database) is about three times as high (11.1 and 3.6 respectively; significantly different means at 1%-level) at universities that engaged in patenting before 2002 compared to those that did not. This indicates that universities with established patenting track records attract professors interested in patenting and/or increase the patent propensity of the professors they employ. Path dependency plays clearly a role.

5.2 First-time inventors

The influence of the new law on the overall patent propensity of professors will be tested by means of how many professors filed a patent for the first time in which year. One third of the individuals (370 out of 986) in the professor database had been involved in patenting activities before 1991. Most of them were based in socialist East Germany, but there were also some professors in West Germany who filed patents before that time. This is a first hint that there seem to be no great patenting barriers. For the remaining 616 individuals I looked up the year of their first patent application.

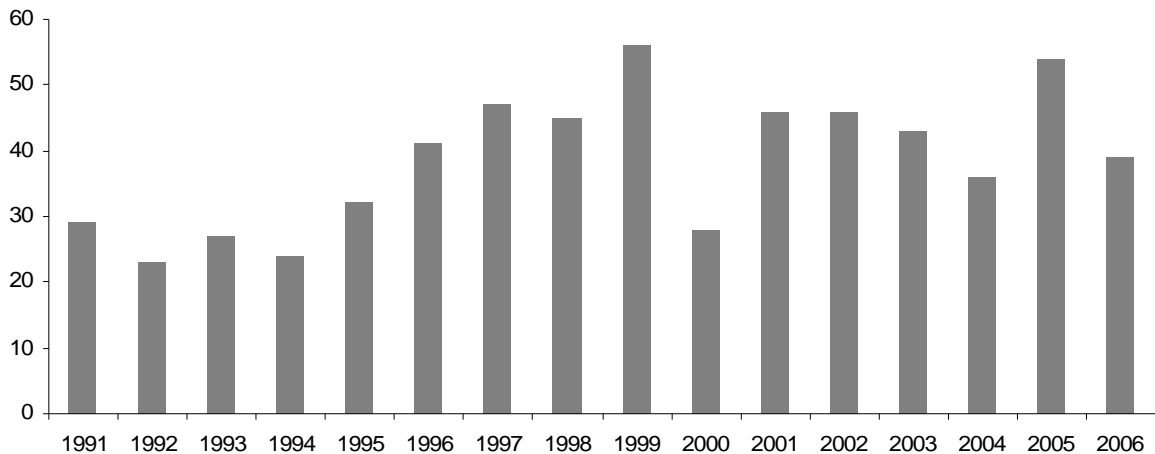


Figure 4: Number of first-time patenting professors per year (not including individuals with patent applications before 1991).

Overall, 398 individuals filed for their first patent between 1991 and 2002 and 218 individuals filed the first patent afterwards. Contrary to what was assumed in the second section, visual inspection (Figure 4) does not suggest a structural break in this time series. This is corroborated by a Chow test: when testing at every point of time if linear regressions for the values before and after that point differ, we do not find a break point around 2002.¹³ There is one in 1995, which can not be related with the legal change. Hypothesis 3 must be rejected.

6 Discussion and conclusions

The paper at hand analyses the development of university-owned patents in the context of the abolition of the professors' privilege and the establishment of TTOs for the first time on a detailed level. The number of university-owned patents has increased in Germany considerably after 2002. Based on a database of university-owned patents with professors as inventors and a second database encompassing all inventions by a selection of German professors with at least one university-owned patent application after 1990, this paper has begun to disentangle the effects of the legislation and of the patent experience, which is closely connected to the transfer infrastructure. Third factor may be an overall increase of academic patenting as it has been observed in several countries, e.g. due to new fields of research where patenting is feasible (especially biotechnology). This trend is taken as the baseline and a systematic change (structural break) is searched for.

The tests suggest that even before university ownership of patents was envisioned by the new law, patent applications by universities accounted for a substantial share of all professors' inventions. The analysis found a structural break in the

¹³ The test on possible break points cannot be conducted for the two data points on each border. Hence, we cannot exclude that there is a break in 2005 or later, but there is no hint for a later break.

number of patents filed by universities in West Germany at the time of the legal change, while there was no such break in East Germany. Further evidence is given by a similar analysis of university-owned patents on inventions of professors active until considerable time after the legal change. The proxies for patent experience in both analyses inhibit some noise. But the similar results strengthen the evidence that transfer infrastructure and experience with patents are crucial.

In an additional analysis there is no evidence for a sudden increase of first-time patenting professors due to the law. This would have been expected if the old legislation was a barrier to secure academic research findings by filing patents. In parallel, patent experienced universities employ a greater number of patent active professors, which is a hint that these universities raised the number of professors commercialising their inventions. The higher number of patent active professors at experienced universities indicates that a well-established patent infrastructure accompanied with a dedicated patent strategy leads to higher numbers of academic patents independently of the IPR ownership law.¹⁴ Because transfer institutions as well as inventing professors have to gain experience in the patent process, we have path dependency in university patenting.

Thus the infrastructure-and-experience hypothesis from earlier literature is supported for Germany, which suggests that if universities endeavour to retain the IPR in the inventions made by their professors, it is facilitated by well-functioning technology transfer intermediaries. In parallel to the enactment of the law, there was an increase in intermediary institutions. They were founded with governmental funds and provide a better financial endowment for patent applications. When the new TTOs have collected experience one can expect a continuously higher level of university-owned patents. Whether there will be a positive trend in the long run depends on other factors like the development of patentable technologies.

From a slightly different perspective, the role of intermediaries suggested by our findings, and the finding that substantial numbers of university inventions were patented by the universities themselves in the past, indicate that university ownership of patents with academic knowledge may not be needed to induce researchers to patent inventions through their employer. If these legal requirements may have negative effects on some technology transfer activities, e.g., the willingness of private sector firms to engage in collaborative research, then a "carrot" approach may be superior to the "stick" approach based on the law.

The paper at hand is a first result in the big task of evaluating the overall effects of the legal reform. Next step will be to look on the whole amount university-invented patents and the shifts in assignment patterns.

¹⁴ Inverted causality of TTOs being established because of an appropriate number of professors interested in patent support cannot be excluded by our analysis.

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