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Input- or output-side changes? The impact of the financial crisis on the patenting activity of firms

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Abstract

The number of international patent filings in many countries has been decreasing during (or even before) the recent economic crisis. The question of which mechanisms within the innovation processes of firms, or on aggregate, innovation systems, are responsible for the decrease in patent filings during the crisis, however, remains unanswered. On the one hand, a decrease in R&D expenditures, indirectly affecting the output side of the innovation process in terms of patentable inventions, might be responsible for the de-cline in patent filings. Yet, also a more direct effect on patenting activity, namely adopt-ing a cost-saving (international) patent strategy, can be assumed.

To test these assumptions, a matched panel dataset on R&D investments and patent activity at the firm level for all companies that have performed R&D in Germany in 2007 and 2009 has been generated. Furthermore, a patent dataset based on the PATSTAT database, including various indicators on the dimensions of changes in patent strategy for ten countries, was developed.

The results show that patent processes have uncoupled from the R&D process during the crisis. Although the effect is comparably small (at least for Germany), it is notable that it can mostly be attributed to a decrease in the correlation between extramural R&D and patent filings. With regard to the changes in patent strategy, it can be observed that especially withdrawing and lapsing patents are prominent cost-saving strategies. The strategy of filing patents at the international level less frequently, however, seems to play a minor role for most patenting companies.

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To test these assumptions, a matched panel dataset on R&D investments and patent activity at the firm level for all companies that have performed R&D in Germany in 2007 and 2009 has been generated. Furthermore, a patent dataset based on the PATSTAT database, including various indicators on the dimensions of changes in patent strategy for ten countries, was developed.

The results show that patent processes have uncoupled from the R&D process during the crisis. Although the effect is comparably small (at least for Germany), it is notable that it can mostly be attributed to a decrease in the correlation between extramural R&D and patent filings. With regard to the changes in patent strategy, it can be observed that especially withdrawing and lapsing patents are prominent cost-saving strategies. The strategy of filing patents at the international level less frequently, however, seems to play a minor role for most patenting companies.

Keywords: patents, crisis, R&D expenditures, firms

1 Introduction

Within this study, the impact of the financial crisis of the years 2008/2009 on the patenting activity of different countries is analyzed. The number of international patent filings in many countries has been decreasing during (or even before) the years of the crisis (Neuhäusler et al. 2013). The impacts of the crisis on patenting are particularly evident in countries that are highly active in the USA - including the United States itself - where the crisis had its point of departure. In countries such as Germany or Japan, the crisis seems to affect patenting less severely, although a reduction in the international patent activity can also be observed particularly in 2008 (Frietsch et al. 2012).

However, it remains unclear what actually drives this decrease in international patent applications. In other words, the question which mechanisms within the innovation processes of firms, or on aggregate, whole innovation systems, are responsible for the decrease in patent filings during the years of the recession is still unanswered.

On the one hand, one can clearly argue that a decrease in R&D expenditures, indirectly affecting the output side of the innovation process, is responsible for the decrease in patent filings during the crisis. Analyses of earlier recessions revealed that firms decrease their investments in R&D during times of crises, which leads to prolonged innovation processes or delayed starts of R&D projects (Rammer et al. 2012). In the long run, the R&D expenditures of most industrialized countries are thus highly sensitive to economic developments (Schasse et al. 2012), although maintaining the given level of R&D expenditures can especially be seen as an advantage of Germany during the recent recession. Yet, also the R&D expenditures of the industry in Germany slightly decreased during the crisis, however not as strongly as in many other countries (Schasse et al. 2012).

Still, in sum, a decrease in R&D investments (input) necessarily leads to a lower number of inventions (output) for which a patent can potentially be filed. This should thus indirectly lead to a decrease in the number of patent filings during the years of the crisis.

In addition, a more direct effect on patenting activity emanating from the economic crisis, namely adopting a cost-saving patent strategy, can be assumed (Frietsch et al. 2012). The economic crisis thus has an influence on the output side of the innovation process itself. In order to decrease costs, firms might have especially changed their international patent strategy during the crisis, as the application and maintenance of patents, especially in several countries or at several patent offices, is associated with enormous costs.

It can thus be assumed that especially larger firms, which are responsible for the lion's share of international patent filings have decided a) not to file their national patent applications (mostly at the home-market) also at an international level. Yet, also keeping patents within the system up to a possible grant and beyond is associated with a given amount of costs (examination fees, processing fees etc.) and therefore firms b) withdraw already filed patent applications or lapse already granted patents more often. Finally, firms might simply choose c) not to file patents for already generated inventions at all and/or delay the filing to a later point in time or to use less expensive ways of intellectual property protection, e.g. secrecy, in case this is possible for the respective inventions or technologies (Blind et al. 2006; Blind et al. 2003; Cohen et al. 2000). All of these strategies are targeted towards saving costs that are associated with the patent process itself.

Especially the strategy of filing patents exclusively at the national level seems to be interesting for companies as patent-active companies file their patents - as soon as they have generated an invention that is worth patenting – in order to decrease the risk of losing their intellectual property to one of their competitors. This makes the strategy of filing patents at the home office comparably inexpensive, as national patent applications are less costly compared to filings at the EPO, via the PCT system or also at another national office, and at the same time less risky since intellectual property protection is secured at the home market.

All in all, this implies that the decrease in (international) patenting is assumed to depend on two mechanisms, which will be analyzed separately within this study to find out a) which of the two assumed effects actually is at place and b) which of the two assumed effects has a stronger influence on the patent activity of firms and, on aggregate, on countries.

2 Data and Indicators

Within this section, we will briefly describe the data and indicators used to analyze changes in patenting during the financial crisis that are associated with the decrease in R&D investments on the one hand and changes in patent strategies on the other.

2.1 Input Side Changes – R&D investments

In order to estimate the influence of a decrease in R&D investments on patent activity during the economic recession an integrated dataset of R&D expenditures and patent applications is necessary. In cooperation with the "Stifterverband für die Deutsche Wis-

senschaft", we have created such a dataset, relating R&D expenditures and patent applications with the help of a probability matching at the firm level (micro data). This integrated dataset allows us to perform differentiated analyses of R&D activities and patenting of German firms in the years 2007 and 2009, which helps us to answer the question if and how strongly a decrease in R&D expenditures affects the patent output of patenting firms during the crisis.

Table 1 Summary Statistics of the integrated R&D – Patent Dataset

Variable	**Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**
Sector (NACE Rev. 2, 2-digit)	2414	23.13	8.81	1	50.00
Employees	2536	1241	7084	0	148938
Sales	2536	371559	2451490	0	55000000
Int. R&D exp.	2536	19390	123211	0	2156573
Ext. R&D exp.	2536	5895	62196	0	1266886
R&D exp.	2536	25285	176020	0	3122645
Patent applications	2536	12.57	99.10	0	2691.00
Forward citations	2536	4.92	45.08	0	1335.00
Patent intensity	2107	0.004	0.019	0	0.50
Citation intensity (R&D)	2107	0.001	0.009	0	0.27
Citation intensity (patents)	1899	0.399	1.501	0	45.00

Source: SV Wissenschaftsstatistik, EPO – PATSTAT.

The dataset is in the form of a firm-level panel. However, not every company shows up twice in the dataset, i.e. for the years 2007 and 2009, implying that the panel is unbalanced. Besides descriptive statistics and analyses of correlations, multivariate statistical panel models for the years 2007 and 2009 will be applied, that allow us to estimate the effect of a decrease in R&D expenditures on patenting, controlling for firm size as well as sector specific effects. We thereby not only focus on the effect of R&D expenditures on patent applications and the change between 2007 and 2009, but also estimate models on patent intensity, defined as the number of patent applications per unit of R&D expenditure and its change over time. Since the dataset also includes information to patent forward citations, which are typically used to estimate the technological quality of patent applications (Albert et al. 1991; Trajtenberg 1990), we will also analyze the effect of decreasing R&D expenditures on patent quality during the crisis. In Table 1, the summary statistics for the dataset are presented.

2.2 Output Side Changes – Patent strategies

In order to analyze the influence of a change in patent strategies on patent activity during the crisis, several indicators based on the PATSTAT database will be analyzed. One specialty of this analysis is that events, e.g. the filing or the withdrawal of a patent, are under observation, which is why we do not analyze patents by priority year but by the year of the respective event, i.e. filing year, year of the withdrawal etc.

Various dimensions of changes in patent strategy are in the focus of the analysis. First, this is the above mentioned strategy of filing patents less frequently at an international level or with a broad market coverage, but more often at the respective national office and in core-markets, in order to protect one's own inventions with less costs. In order to find out if this strategy is actually more frequently used by patent applicants during the crisis, a newly developed indicator, namely the share of transnational patent filings on the number of distinct patent families[1] (including patent families with only one member, which are commonly referred to as "singletons" (Martinez 2009)) is calculated. Yet, as already stated above, there are other cost-saving strategies than just decreasing the number of international patent filings. One of these is to withdraw already filed patents or lapse already granted patents to save examination or maintenance costs. In order to capture these effects with the patent data at hand, two additional indicators are calculated and analyzed, which enables us to draw conclusions about such kinds of strategies during the crisis. This is first of all the share of withdrawn patents on the number of patent filings that are within the EPO system in a given year. In order to define the number of patents that currently are within the EPO system, first of all the stock of patent filings up to the year 1991 minus granted, withdrawn and refused patents was calculated. From 1992 onwards the difference of yearly inflows of patent filings and yearly outflows in terms of grants, refusals and withdrawals was calculated and added to the stock of patents within the EPO system before 1992. This indicator thus informs us if the withdrawal shares actually increased during the crisis. Second, we calculate the yearly share of lapsed patents in the existing stock of granted patents. The basic method in calculating the stock of granted patents per year is similar to the withdrawal share. First, we calculate the stock of patent grants up to the year 1991 minus lapsed patents. From 1992 onwards the difference of yearly inflows of patent grants and yearly out-

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1 Patents for the same invention that are filed at several patent offices are commonly called patent families. A patent for the same inventions that is for example filed in Germany, the USA and Japan is called a patent family with three members.

flows in terms of lapses is added to the stock of patents within the EPO system before 1992. However, EPO patents are forwarded to the national offices after grant and the maintenance fees have to be paid to the national offices. We thus decided to count a patent as lapsed when it has been lapsed at the German Patent and Trademark Office (DPMA), as we cannot control for the lapses at each office without double-counting. Yet, tests show that the share of lapsed patents is very similar also when looking at lapse shares at the UK Intellectual Property Office (IPO) or the French Intellectual Property Office (INPI) compared to the DPMA.

Table 2 Summary Statistics for the Patent Dataset

Variable	**Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**
Transnational share	27761	0.61	0.32	0.002	1
Withdrawal share	30810	0.05	0.08	0	1
Lapse share	25499	0.11	0.16	0	1
Technology field	37050	20.00	11.25	1	39
Country	37050	5.50	2.87	1	10
Year	37050	2001	5.48	1992	2010
Applicant type	37050	3.60	3.26	0	8

Source: EPO – PATSTAT.

It is possible that those patent strategies differ between different countries[3], technology fields as well as between different types of applicants (SMEs, large firms, universities, public research institutes, single inventors) due to differences in resource constraints. Thus, we have created a dataset that allows us to estimate multivariate panel models at the level of countries and high-technology fields – in addition to descriptive statistics – on the three outcome indicators described above controlling for field and country[2] specific effects as well as effects that might be moderated by the type of the patent applicant[3]. With the help of those models, differentiated conclusions about the influence of the crisis on different patent strategies can be drawn.

In sum, this two stage analysis allows us to assess, at least for Germany, which of the two mechanisms (direct vs. indirect) exerts a stronger influence on patenting during the economic crisis. An overview of the variables used for our analyses can be found in Table 2.

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2 The countries covered by the sample are CH, DE, FI, FR, GB, IT, JP, NL, SE and the US.

3 We control for several types of patent applicant, namely SMEs (less than 500 employees), large firms (more than 500 employees), universities, public research institutes and single inventors.

3 Results of the Analyses

This section presents the results of the analyses on the impact of the financial crisis on patenting activities. First, we will focus on the question if and how the R&D downturn during the crisis affects the patenting activities. Second, the results of the change in patent strategy on patent output will be presented.

3.1 The effect of R&D on patenting during the crisis

To get a first impression of the impact on the financial crisis on the R&D expenditures, and, in turn, the patent activities of German firms, Table 3 shows the correlation coefficients between R&D expenditures and patent applications as well forward citations and its changes between 2007 and 2009. As we can see from the table, the correlation between the total R&D expenditures and the number of patent applications decreases between 2007 and 2009. This can be seen as a first indication of our assumption that the crisis affects the input of the innovation process in terms of R&D expenditures and accordingly also the output. In 2009, the patent process can be shown to be more uncoupled from the R&D process than it was in 2007. Interestingly, this decrease of the correlation between total R&D expenditures and patent filings can be attributed to a decrease in the correlation between extramural R&D expenditures and patent filings, whereas the correlation between intramural R&D expenditures and patents nearly remains unchanged.

Table 3 Correlation Analysis

		Intramural R&D expenditures	Extramural R&D expenditures	Total R&D expenditures
Nr. of patent filings	2007	0.754***	0.569***	0.726***
	2009	0.758***	0.405***	0.678***
Nr. of forward citations	2007	0.725***	0.444***	0.668***
	2009	0.697***	0.548***	0.678***

Significance level: ***p<0.01, **p<0.05, *p<0.1.

Source: SV Wissenschaftsstatistik, EPO – PATSTAT.

When looking at the number of forward citations to patents, which can be seen as an indicator of patent quality (Albert et al. 1991; Trajtenberg 1990), we find a slight increase in the correlation coefficient between 2007 and 2009. This increase can also be attributed to projects financed by extramural R&D. In the case of intramural R&D expenditures, the correlation slightly decreases. In sum, this means that firms mostly seem to decrease their extramural R&D activities during the crisis.

Table 4 Multivariate Results I

	Number of patent applications XT negative-binomial, RE			**Number of FW-citations** XT negative-binomial, RE		
	Coef.		Std. Err.	Coef.		Std. Err.
R&D expenditures	0.0000013	***	0.0000001	0.0000017	***	0.0000002
2009 Dummy	-0.0968796	***	0.0355312	-2.6619220	***	0.1308692
R&D expenditures*2009 Dummy	-0.0000001	**	0.0000000	-0.0000002	**	0.0000001
Firm Size Dummy	1.1351260	***	0.0684225	1.941	***	0.145
Constant	0.5837710	***	0.0953379	-0.294		0.274
Sector Dummies	YES			YES		
Nr. of obs.	2370			2370		
Nr. of groups	1633			1633		
LR chi2/Wald chi2	611.44			1502.91		
Prob > chi2/Wald chi2	0.000			0.000		
Pseudo R2	0.042			0.019		

Significance level: ***p<0.01, **p<0.05, *p<0.1.

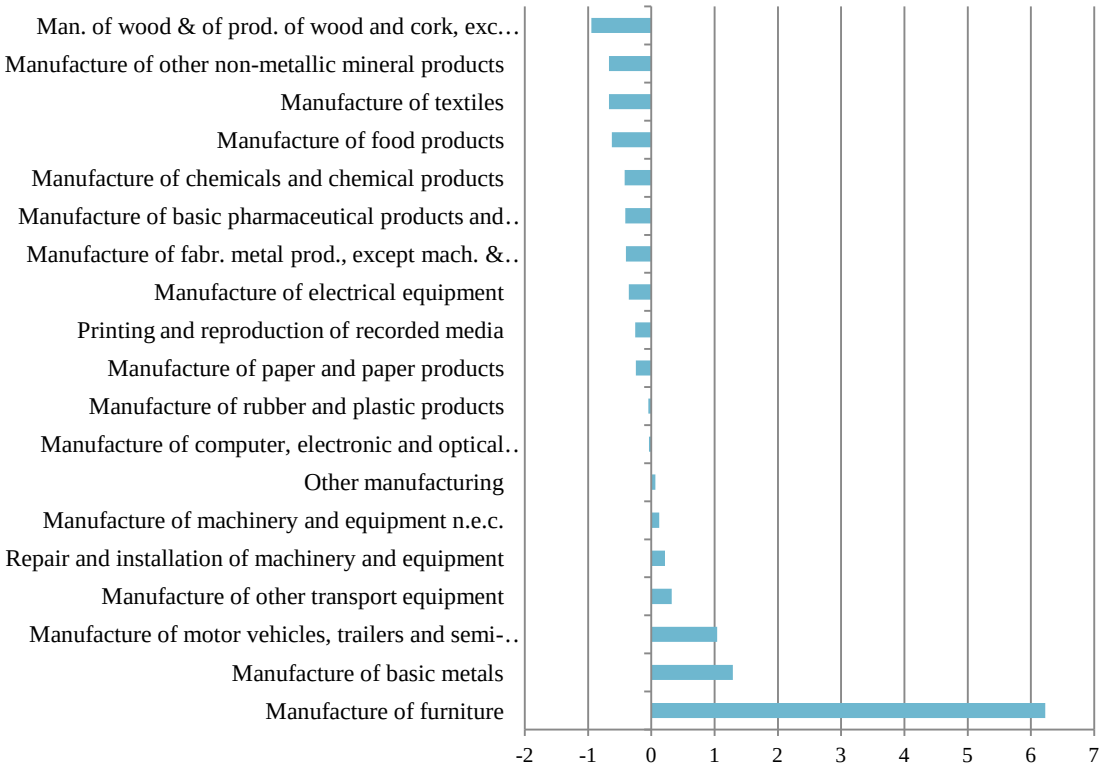
Source: SV Wissenschaftsstatistik, EPO – PATSTAT.

When analyzing these trends via a multivariate regression model, similar effects can be observed. Using the number of transnational patent filings as the dependent variable and R&D expenditures, a dummy for the year 2009 (as compared to 2007) as well as the interaction term between R&D expenditures as explanatory variables controlling for firm size - coded 0 for firms with less than 500 employees - and sectors, we find that there is a positive relationship between R&D expenditures and patents, which is as expected.[4] For the year 2009, we find a significantly negative effect compared to 2007, which is the base outcome for this dummy variable, implying that the number of patent applications is decreasing between 2007 and 2009. Most interesting for our question if a decrease in R&D expenditures has led to the decrease in patent filings is the interaction effect between R&D expenditures and the year 2009, whose coefficient shows a significantly negative sign. This means that at least a part of the decrease in patent filings during 2007 and 2009 can be attributed to a decrease in R&D expenditures, although other factors are at play here, which is shown by the significantly negative effect of the dummy variable for the year 2009.

4 In previous analyses with this dataset, we have found that not using a time-lag between R&D expenditures and transnational patents delivers results with the highest explanatory power. This is why we have decided not to use a time-lag between R&D expenditures and patent filings for the analyses at hand.

In sum, we can state that there is an effect of a decrease in R&D expenditures on the decrease in patent filings, although the effect is not overly large. We observe exactly the same pattern for the forward citations, too, implying that a higher amount of R&D leads not only to a significant increase in patent filings but also to an increase in patent quality. The dummy variable for the year 2009 as well as the interaction term also show negative signs in this model and the effects are more strongly pronounced than in the model on patent filings. Thus, the decrease in R&D during the crisis slightly decreases the patent filings but even more so the patent quality, as indicated by a decline in patent citations.

Figure 1 Growth of the patent intensity between 2007 and 2009, by sector, industry only



Source: SV Wissenschaftsstatistik, EPO – PATSTAT.
Note: Calculations only for sectors that state a given patent intensity in 2007 and 2009.

Figure 1 now shows the growth of the patent intensity – calculated as the number of transnational patent filings by unit R&D expenditure – between 2007 and 2009. As we can see from the figure, the patent intensity decreases or stays at a comparable level in the manufacturing sector between 2007 and 2009. Yet, there are some exceptions from this pattern. Mostly the mechanical engineering related sectors, especially the transport

sector but also the basic materials industry, even show growing patent intensities during this time period. The largest growth can be found for the manufacture of furniture, although this is a rather small industry in terms of total R&D expenditures. It thus seems that in most sectors, a decrease in R&D expenditures also leads to a decrease in patent filings. When we take a closer look at this effect by estimating a multivariate random-effects panel model with the patent intensity as the dependent variable and sector specific controls as well as a control variable for firm size (coded 0 for firms with less than 500 employees), we see that on average the patent intensity decreases between 2007 and 2009 (Table 5).Yet, the effect is not significant in the OLS model and only marginally significant in the Tobit model. As for the citation intensity – calculated as the number of patent forward citations divided by the R&D expenditures – some more stable effects can be observed. Here, we also find that on average the citation intensity decreases between 2007 and 2009. The effect is stable over both model specifications and shows a larger coefficient than for the patent intensity. This confirms the results from the previous model. Although the decrease of R&D expenditures on the financial crisis affects a company's patent output on average, the negative effect is more strongly pronounced when looking at patent quality rather than quantity. However, due to the timeliness of R&D expenditures and patent filings, the effects of the economic crisis on patent intensity are hard to validate and interpret.

In sum, we can state that during the crisis, patent processes start to uncouple from the R&D process, although this is mostly a consequence of a decrease in R&D expenditures in extramural R&D projects. This might be an effect of lowering especially variable costs (extramural R&D) while keeping the fixed costs (intramural R&D) at a similar level. Firms might have learned from the new economy crisis to keep up a certain level of R&D capacities in order to be prepared for the periods after the crisis, e.g by not having increased search costs. The models also show at least a part of the decrease in patent filings of German firms between 2007 and 2009 can be attributed to a decrease in R&D expenditures, which confirms our hypothesis, although the effect is not overly large. As for the patent quality, on the other hand, the effect is more strongly pronounced, implying that a lower amount of R&D leads not only to a significant decrease in patent filings but also to a decrease in patent quality. However, the models also show that the decrease in R&D expenditures is not the only factor that leads to a decreasing patent output during the crisis. These factors might be associated to changes in patent strategy of the firms, which will be analyzed in the next section.

Table 5 Multivariate Results II

	Patent intensity						Citation intensity					
	XT OLS, RE			XT Tobit, RE			XT OLS, RE			XT Tobit, RE		
	Coef.		S.E..	Coef.		S.E.	Coef.		S.E.	Coef.		S.E.
Firm Size Dummy	-0.004	***	0.001	-0.0002		0.001	-0.001	*	0.001	0.010	***	0.002
2009 Dummy	-0.001		0.001	-0.002	†	0.001	-0.002	***	0.000	-0.018	***	0.001
Constant	0.005	***	0.001	-0.001		0.001	0.002	***	0.000	-0.017	***	0.002
Sector Dummies	YES			YES			YES			YES		
Nr. of obs.	2017			2017			2017			2017		
Nr. of groups	1414			1414			1414			1414		
LR chi2/Wald chi2	94.37			--			40.04			--		
Prob > chi2/Wald chi2	0.000			--			0.6005			--		
Pseudo R2	0.047			0.000003			0.020			0.009		

Significance level: ***p<0.01, **p<0.05, *p<0.1, †=marginally significant.

Source: SV Wissenschaftsstatistik, EPO – PATSTAT.

3.2 The effect of changing patent strategies on patent output

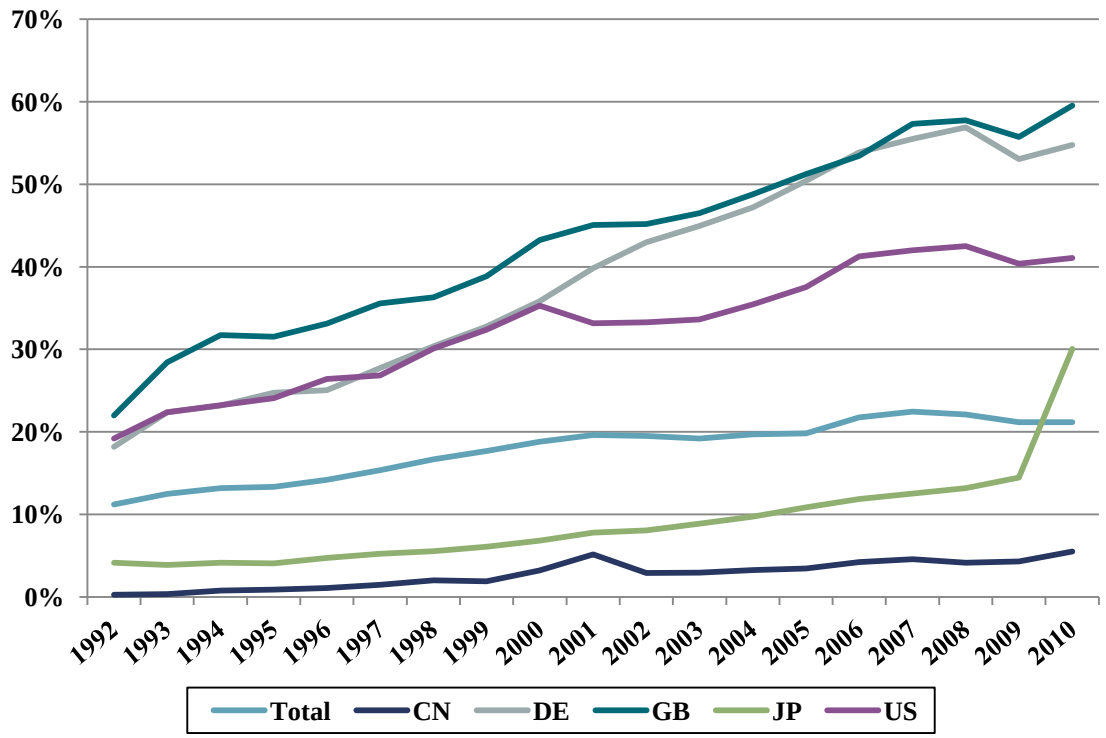
Within this section, we will analyze the effect of changes in patent strategy during the crisis on the patent output of countries (as an aggregate of all patent filings within the country, which mostly come from industry). As already stated in the introduction, we can assume that firms have adopted a cost-saving patent strategy during the crisis, which consequently influences their output in terms of patent filings. However, we do not know what kind of strategies firms exactly follow in order to save patenting costs. We thus make three assumptions about reasonable cost-saving strategies that firms might follow during the crisis and then test these assumptions via descriptive as well as multivariate analyses.

As we can observe that especially transnational patent activities are declining for most countries during the crisis, a first cost-saving strategy of firms could be to file their patent applications only at the home-market and not at an international level. This spares the costs of a rather expensive international filing but still has a rather low risk as intellectual property protection is secured at least at the home market. In order to test this assumption, we calculated the share of transnational patent filings by application year on the number of patent families (including "singletons") of a country. By applying this indicator and analyzing it over time, we are able to find out if the share of international filings (via the PCT and/or EPO system) on all patent filings of firms (national at the home-market, national at a foreign market or transnational) have decreased during the

crisis. This gives us an indication of "international orientation" of the firms in terms of their patent strategy.

The share of transnational patent filings on the number of patent families is plotted graphically in Figure 2. As we can see, the share is mostly rising over the years for all analyzed countries, although the growth is highest in the 1990s. After the year 2001, where we encountered the new economy crisis, we can observe a slowdown in this growth and the share remains rather stable until 2005. Afterwards, we find a slight increase until 2006 and once again a slowdown of the growth from 2007 onwards where the financial crisis started. This effect confirms our hypothesis at least partly, although the effect is not that strongly pronounced. Especially for the US we find the expected pattern. For the UK and Germany the effects are also as expected. Yet, for China and Japan, we do not find the assumed decrease in international filings.

Figure 2 Share of transnational patent filings on patent families, by filing year, 1992-2010

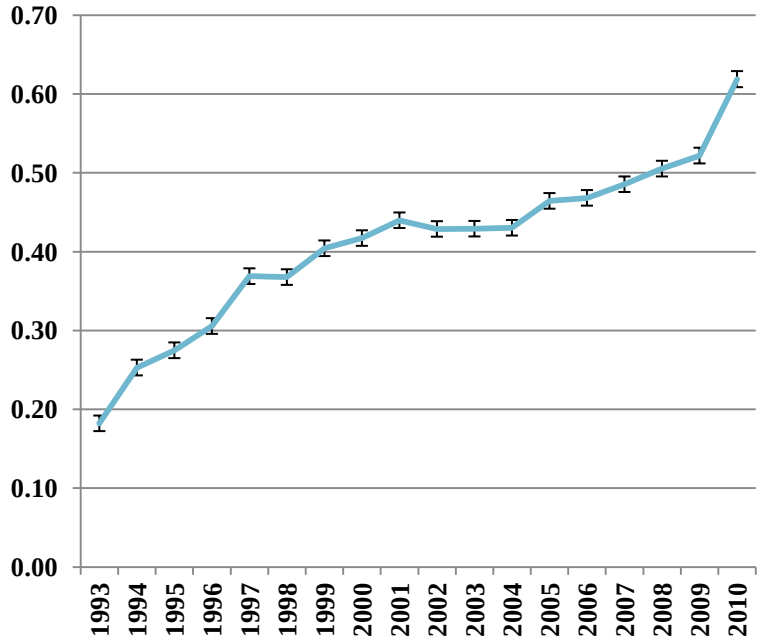


Source: EPO – PATSTAT.

The effects of the multivariate model with the share of transnational patent filings on the number of patent families as a dependent variable as well as control variables for coun-

tries, technology fields and the size of the patent applicant (Figure 3) show a similar trend.[5] We observe a drop in the share after 2001, which is also significant as the F-Test compared to the year 2000 shows. However, we do not find the expected decrease in the share between 2007 and 2009 when controlling for country-, size- and field-specific differences. The share rather seems to even slightly increase within this time period.

Figure 3 Development of the coefficient (incl. standard errors) of filing year in the multivariate model on the share of transnational patent filings on patent families, 1993-2010, base year 1992



Year	F-Test (compared to previous year)
1994	50.1***
1995	4.73**
1996	9.36***
1997	39.83***
1998	0.01
1999	13.6***
2000	1.72
2001	5.34**
2002	1.28
2003	0.00
2004	0.01
2005	12.05***
2006	0.15
2007	3.11*
2008	4.03**
2009	2.76*
2010	90.81

Source: EPO – PATSTAT.

Note: Tobit panel-model, marginal effects, dV: share of transnational patent filings on patent families, iVs: filing year (base: 1992), technology fields, type of patent applicant, countries.

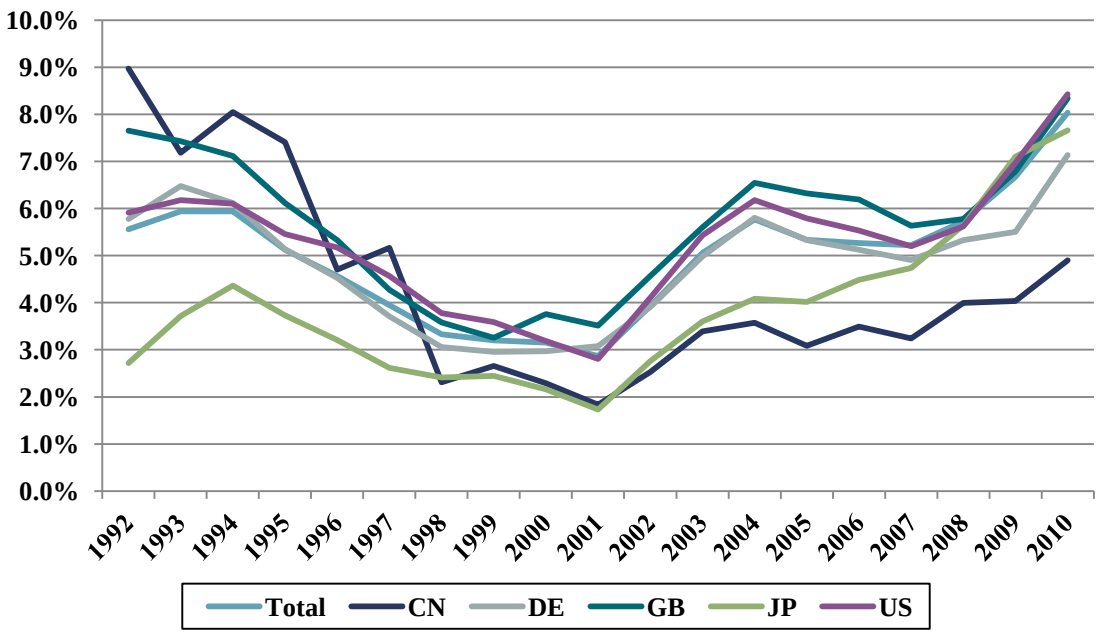
In sum, we can state that we can only partly confirm the hypothesis of a decrease in international compared to national patent activities. Also a slight decline in international patent activities can be found during the recession, it seems that companies, in order to save costs, rather delay the patent filing in general, or not file their patent at all, rather than filing a patent at the home-market and not at the international level. Only for some

5 The full results of the models can be consulted in Table A 1 in the annex.

countries, like for example the USA, which has a very large domestic market, this seems to be a suitable strategy.

Yet, also keeping patents within the system up to a possible grant is associated with a given amount of costs (examination fees, maintenance fees etc.) and therefore firms might withdraw already filed patent applications more often than usual during times of crises. This is the second cost-saving strategy that is under analysis here, which will be analyzed by the development of the share of withdrawn patents in the EPO patent stock over time (Figure 4). As we can see from the figure, the share of withdrawn patents is declining in the 1990s for all of the analyzed countries, implying that within this time period, patents are more and more kept within the EPO system up to a possible grant. Yet, from 2001 to 2004, i.e. within the period of the new economy crisis, the withdrawal share is rising in each of the countries under analysis. From 2004 onwards, we observe a decline in this ratio until 2008, where the share of withdrawn patents once again drastically increases. This pattern can be seen as a confirmation of our hypothesis. During both economic crises, the share of withdrawn patents increases and decreases afterwards.

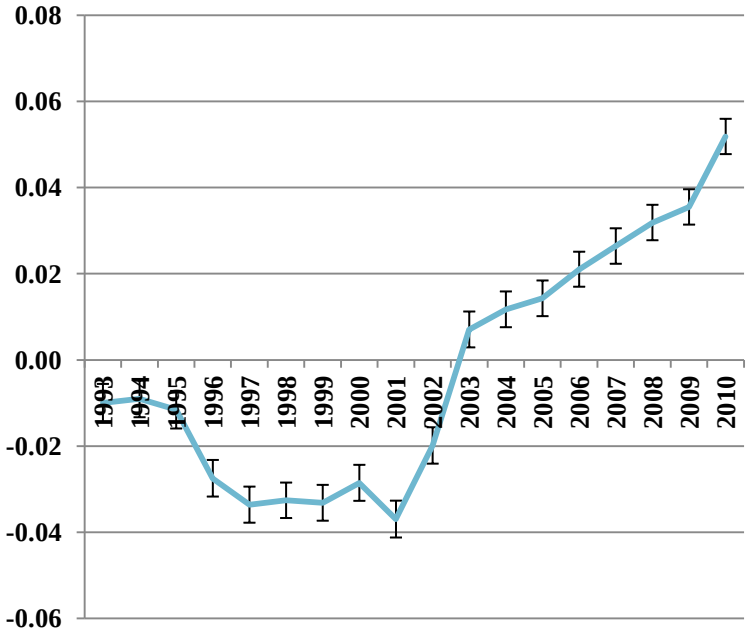
Figure 4 Share of withdrawn patents in the EPO patent stock, by year of withdrawal, 1991-2010



Source: EPO – PATSTAT.

Also when looking at the multivariate model, where we control for countries, technology fields and the size of the patent applicant, a similar trend can be observed (Figure 5). Especially during times of the two economic crises, we find a drastic increase in the coefficient. The F-Test shows that these effects are significant on a yearly basis only for the crisis of the new economy as well as for the year 2010 (as compared to 2009). However, when grouping the years according to the times of the crises, i.e. 1990-2000, 2001-2003, 2004-2007, 2008-2010, we find significant differences between all the groups.

Figure 5 Development of the coefficient (incl. standard errors) of withdrawal year in the multivariate model on the share of withdrawn patents in the EPO patent stock, 1993-2010, base year 1992



Year	F-Test (compared to previous year)
1994	0.05
1995	0.37
1996	14.76***
1997	2.42
1998	0.07
1999	0.02
2000	1.47
2001	4.48**
2002	18.04***
2003	47.74***
2004	1.5
2005	0.46
2006	3.35*
2007	2.16
2008	2.16
2009	0.96
2010	19.77***

Source: EPO – PATSTAT.

Note: Tobit panel-model, marginal effects, dV: share of withdrawn patents in the EPO patent stock, iVs: withdrawal year (base: 1992), technology fields, type of patent applicant, countries.

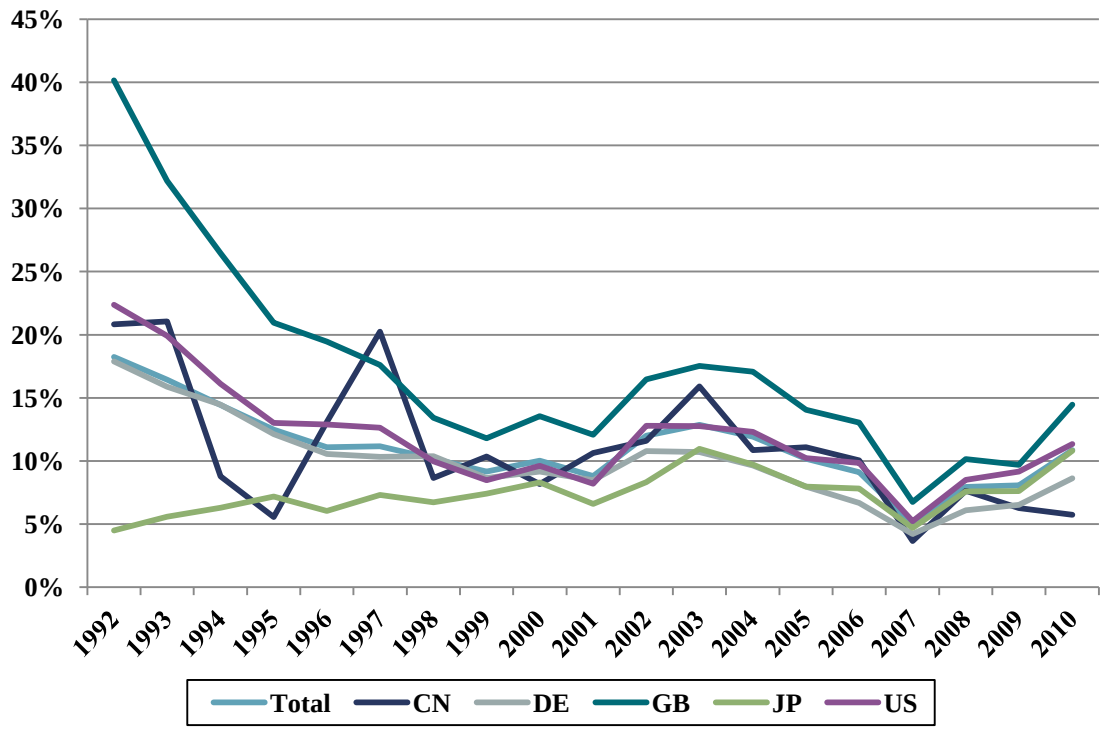
It thus seems that withdrawing patents that are already within the system but not yet granted seems to be a very suitable and commonly used cost-saving strategy for firms, which is applied especially during times of economic crises, where cost-saving strategies become more important. This makes sense from a company point of view since a once filed patent becomes state-of-the-art, which makes it impossible for other companies to file a patent for the same invention. In addition, the patent has an option value

until it is withdrawn from the system, which often is sufficient especially in very quickly paced technology fields.

The final cost-saving strategy of companies that we analyze here is to lapse already granted patents more often than usual during times of crises. For each granted patent, maintenance fees have to be paid to the respective national offices, which can be very expensive especially when maintaining a patent at a large number of national offices. The share of lapsed patent filings in the stock of granted EPO patents is plotted in Figure 6.

As we can see from the figure, the share of lapsed patents is declining over the 1990s, with the exception of Japan. This trend is in accordance with the withdrawal shares shown above. Until the year 2000, firms have thus more commonly kept their patents within the system, before as well as after grant. From 2001 until 2003, the share of lapsed patents is increasing and once again declines afterwards. From 2007 onwards, however, the shares are increasing again. This pattern could also be observed for the shares of withdrawn patents and indicates that lapsing patents in order to save costs also seems to be a suitable patent strategy.

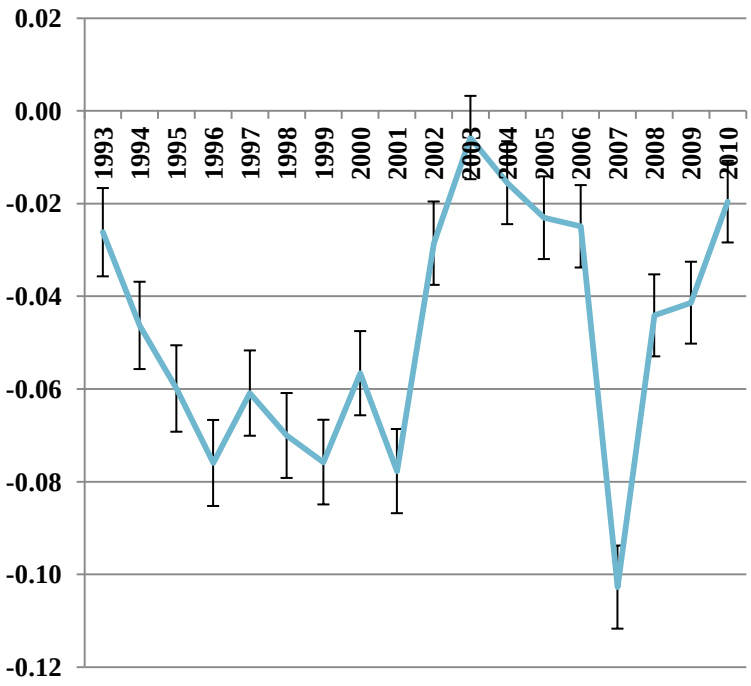
Figure 6 Share of lapsed patent filings in the stock of granted EPO patents, by year of the lapse, 1991-2010



Source: EPO – PATSTAT.

The period-specific effects from the multivariate model, where we control for countries, technology fields and the size of the patent applicant, point into a similar direction to what could be shown by the descriptive analysis (Figure 7). During both economic crises, we find a drastic increase in the coefficient, implying that the share of lapsed patents increases during the recessions, keeping all other factors constant. The F-Tests show that these effects are significant on a yearly basis for both economic crises. Also when grouping the years according to the times of the crises we find significant differences between all the groups.

Figure 7 Development of the coefficient (incl. standard errors) of lapse year in the multivariate model on the share of lapsed patent filings in the stock of granted EPO patents, 1993-2010, base year 1992



Year	F-Test (compared to previous year)
1994	4.70**
1995	2.25
1996	3.24*
1997	2.94*
1998	1.11
1999	0.45
2000	5.09**
2001	6.26**
2002	34.73***
2003	7.67***
2004	1.42
2005	0.87
2006	0.05
2007	92.58***
2008	53.19***
2009	0.12
2010	7.75***

Source: EPO – PATSTAT.

Note: Tobit panel-model, marginal effects, dV: share of lapsed patent filings in the stock of granted EPO patents, iVs: lapse year (base: 1992), technology fields, type of patent applicant, countries.

In sum we can state that both strategies, i.e. withdrawing and lapsing patents more frequently during times of crises, are prominent in order to save costs. The strategy of filing patents less frequently also internationally, however, does not seem to play a major role for most of the countries under analysis. Patent filings rather seem to be filed with a

delay or maybe not even filed at all during the economic recession. Patents that are already within the system, however, are withdrawn (before grant) or lapsed (after grant) more frequently.

4 Conclusions

Within this study, the impact of the financial crisis of the years 2008 and 2009 on the patenting activity of different countries was in the focus. We followed a two-step approach in order to find out if the decline in patent activities could solely be attributed to changes at the input side of the patent process, i.e. a decrease of R&D expenditures during the recession, or if special cost-saving patent strategies are additionally able to explain the decline in the patent output of countries.

What we find is that during the crisis, patent processes start to uncouple from the R&D process. This can mostly be seen as a consequence of a decrease in R&D expenditures in extramural R&D projects. A part of the decrease in patent filings of German firms during 2007 and 2009 can thus be attributed to a decrease in R&D expenditures, which confirms our hypothesis, although the effect is not overly large. As for the patent quality, on the other hand, the effect is more strongly pronounced. However, the models also show that the decrease in R&D expenditures is not the only factor that leads to a decreasing patent output during the crisis. The further analyses show that changes in the patent strategy of the firms serve as an explanation for the decrease in patent applications during the recession. Especially withdrawing and lapsing patents more frequently during times of crises are prominent cost-saving strategies. The strategy of filing patents less frequently also internationally, however, rather plays a minor role for most of the countries under analysis. Patent filings rather seem to be filed with a delay or maybe not even filed at all during the economic recession. Patents that are already within the system, however, are withdrawn (before grant) or lapsed (after grant) more frequently.

The analysis has thus provided us with a detailed view on the factors that are driving the decrease in patent filings during the economic recession. We have learned that both, a decrease in R&D expenditures as well as a change in patent strategies, are behind the decrease in patent filings. This has two kinds of implications. The first one is associated to the measuring of innovative activities via patent indicators during times of recession, especially as patent processes seem to uncouple from the R&D expenditures and patent strategies are adapted. Measuring innovative activities solely by patents could lead to a distorted picture of the innovative output of companies and firms especially during recessions. Thus, especially for analyses of technological performance of countries during

crises, an innovation indicator system, including several input as well as output related indicators for innovation should be applied to draw a complete picture. When using patent indicators alone as a measure of innovative output, this has to be kept in mind for the interpretation of these indicators. The second implication is that R&D is not the only factor that drives the decrease in patent filings. Firms are well able to develop differentiated cost-saving patent strategies, which increase their room to maneuver also when costs have to be cut in order to stay competitive, at least for a certain amount of time. This implies that firms, at least in Germany, have been able to cope with the crisis while maintaining a certain level of innovative potential.

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Annex

Table A 1 Multivariate Results III

	Share: Transnational filings/patent families			Share: Withdrawn patents/EPO filing stocks			Share: Lapsed patents/EPO grant stocks		
	Coef.		S.E.	Coef.		S.E.	Coef.		S.E.
1993	0.182	***	0.010	-0.010	**	0.004	-0.026	***	0.010
1994	0.253	***	0.010	-0.009	**	0.004	-0.046	***	0.009
1995	0.275	***	0.010	-0.012	***	0.004	-0.060	***	0.009
1996	0.306	***	0.010	-0.027	***	0.004	-0.076	***	0.009
1997	0.369	***	0.010	-0.034	***	0.004	-0.061	***	0.009
1998	0.368	***	0.010	-0.033	***	0.004	-0.070	***	0.009
1999	0.404	***	0.010	-0.033	***	0.004	-0.076	***	0.009
2000	0.417	***	0.010	-0.029	***	0.004	-0.057	***	0.009
2001	0.440	***	0.010	-0.037	***	0.004	-0.078	***	0.009
2002	0.429	***	0.010	-0.020	***	0.004	-0.029	***	0.009
2003	0.429	***	0.010	0.007	*	0.004	-0.006		0.009
2004	0.430	***	0.010	0.012	***	0.004	-0.016	*	0.009
2005	0.464	***	0.010	0.014	***	0.004	-0.023	**	0.009
2006	0.468	***	0.010	0.021	***	0.004	-0.025	***	0.009
2007	0.485	***	0.010	0.026	***	0.004	-0.103	***	0.009
2008	0.505	***	0.010	0.032	***	0.004	-0.044	***	0.009
2009	0.522	***	0.010	0.035	***	0.004	-0.041	***	0.009
2010	0.619	***	0.010	0.052	***	0.004	-0.020	**	0.009
Constant	0.213	***	0.012	0.078	***	0.005	0.183	***	0.011
Field Dummies	Yes			Yes			Yes		
Country Dummies	Yes			Yes			Yes		
Applicant Type Dummies	Yes			Yes			Yes		
Number of obs.	27761			30810			25499		
LR chi2	28329.68			5071.12			2297.52		
Prob > chi2	0.000			0.000			0.000		
Pseudo R2	0.7465			-0.3619			0.2505		

Significance level: ***p<0.01, **p<0.05, *p<0.1. Tobit panel-models, marginal effects. The base year for the time-dummies is 1992.

Source: EPO – PATSTAT.