Firms’ cooperative activities as driving factors of patent declaration on technological standards

Evidence from firm level analysis on cooperative arrangements and business models

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ABSTRACT

In complex technologies, IPR is owned among several firms and technical innovation often overlaps. In situations of divided technical leadership cooperative activities are crucial to influence the innovation trajectories. Standardization is a process to commonly agree on a technology that might also include essential IPR. This article investigates the patenting behavior of 250 essential patent owning companies in international standard bodies. Over 60,000 patent declarations were analyzed on firm level to show how cooperative activities influence the inclusion of patents in a standard. The theoretical model of tactic collusion suggests an increase of patent declaration when cooperative activities among firms increase. Our empirical results show that the involvement in related standards consortia as well as being a licensor in patent pools favors patent declaration. Contrary to this, companies involved in R&D cooperation among essential patent owning companies, tend to declare fewer patents on standards. Furthermore the analysis of the firms’ business models reveals that non-practicing entities favor patent declarations on standards.

KEYWORDS cooperative activities, standards consortia, patent pools, essential patents

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INTRODUCTION

In the past ten years theoretical and empirical research about the interplay of IPR and technological standards has been increasing and as a consequence revealed new implications for microeconomic analysis. On the one hand this is due to the growing importance of technological standards in our interconnected information and communication society, where interoperability and common agreement on a technology is crucial to unlock innovation (Blind & Gauch, 2008). On the other hand recent problems of IPR and standards such as hold-up or patent ambush behavior have caused expensive litigation cases and raised the question about the driving factors of patent declaration (Hovenkamp, 2008; Bensen & Levinson, 2009; Opitz & Pohlmann, 2009).

Especially in the field of ICT (Information and Communication Technology), standards frame innovative technologies that develop over time. These standards are not static but rather develop to be highly innovative and constantly change in their technological scope (e.g. GSM, UMTS, Wi-Fi (IEEE 802.11), MPEG). Therefore the number of patents on commonly agreed standards has increased strongly during the last decades (Bekkers et al., 2001; Simcoe, 2005). Especially in the context of patent thickets, which is a web of overlapping patents, empirical studies evidence an excessive patent filing behavior for certain technologies. The assumption is that companies try to protect their innovation with a preferably high number of patents. This phenomenon can most often be identified in standard related industries and in particular in the field of ICT. The increasing complexity of patent files may cause coordination problems and in cases of hardship even leads to litigation (Shapiro, 2001). Patents that are essential to a standard are these that one would necessarily infringe when the standard is implemented. Firms that participate in the standardization process have to commonly agree on which technologies to include and thus also agree which patent will affect the standard.

There are three forms of firm coalition that accompany the standardization process: standards consortia, patent pools and R&D cooperation. Standardization is an agreement of several parties to promote a certain technology. Cooperative activities such as membership in informal consortia, being a licensee or licensor in patent pools or entering R&D cooperation might thus influence the mutual consent on patents that are declared to be essential.

A standard consortium is a group of firms, which produces standards on an informal, but more flexible and frequent level (Cargill 2002, Blind & Gauch, 2008). During the last years, upcoming informal standards consortia play an important role in the standard setting arena and cause new challenges for coordination, since IPR rules and licensing arrangements are very diverse and not always transparent (Cargill, 2002; Updegrove, 2010; Pohlmann, 2010).

Patent pools are consortia to solve problems of patent blocking and coordination, by pooling all patents to agree on a single license contract. R&D cooperation is a collaboration of basic research, where firms consolidate resources and share certain knowledge to effectively work on a common project. Joint R&D cooperation usually accrue to conduct research, where in contrast participating firms in informal standards consortia may already have developed technology, or in patent pools where the specific research is completed and only licensed out.

Recent empirical research already gives evidence that the number of essential patents is influenced when formal standards can be connected to a patent pool or standards consortia (Baron & Pohlmann, 2010). This paper empirically measures the effects of firms' cooperative arrangements on the inclusion of patents. We construct a dataset that combines membership information of over 150 standards consortia, 45 patent pools and over 2000 R&D cooperation over the last ten years. Using panel analysis, we compare these memberships with 250 essential patent owning companies, which state more than 60,000 patent declarations to all international standard bodies. We furthermore classify the companies by their vertical integration since motives to patent may especially depend on the firms' business model.

This article is structured as follows. We start with a discussion of the relevant literature and construct our theoretical model to derive our hypothesis. In the following we present our database and analyze first descriptive results. To strengthen our argumentation, we run econometric regressions, discuss the robustness of our investigation and present the outcome. In conclusion, we test our previous hypothesis, discuss our results and give policy implications.

THEORETICAL BACKGROUND AND HYPOTHESIS

The interplay of patents and standards concerns several aspects of economic research and is a good mechanism to analyze microeconomic problems. However, there has been little investigation on firm level data and cooperative activities to explain excessive patenting on formal standards.

The literature indicates that there are incentives for entities to introduce their patents in a standard. In the case of GSM, Bekkers et al. (2002) found out that the number of patents owned by a network player improves its market position. Furthermore Rysman & Simcoe (2006) showed that patents included in a standard receive a higher number of cites. Evidence from Köhler et al. (2010) identified a strategic patent filing behavior of essential patents. Nevertheless, Blind et al. (2010) found out that companies use essential patents to collaborate in standard setting and not to gain license fees. Still, there has not been any empirical research that considers the firms' vertical integration. Since many litigation cases of IPR infringement in the standard context have identified a certain bargaining position for non-practicing entities (Opitz & Pohlmann 2009), this paper aims to distinguish between vertically integrated manufacturers and non-producers. We assume that entities without vertical integration only use their patents to sell or license them to third parties, since they are not active on downstream markets. An inclusion of the patent to be essential to a standard would increase the value of the patent for higher royalties or a higher selling price. Therefore this paper tries to find evidence for the hypothesis:

H1: Non-practicing entities tend to declare more patents on formal standards!

In order to better understand the interplay of IPR and standards one also has to consider company's cooperation activities that can be related to standardization and patent filing behavior (Baron & Pohlmann, 2010). The decision of declaring a patent on a formal standard is a common agreement by all standard developing companies in the respective working group. Cooperative activities connected with the standard setting process might hence have an influence on the decision of essential IPR. We therefore use a theoretical approach to better explain possible implications of firms' interaction and common agreement. Thus we are able to identify three interest groups, which accompany formal standardization:

Informal standards consortia:

Formal standard bodies recently had to face a new method of standardization. The standard setting arena is divided into formal standard bodies and informal standards consortia that work on complementary technologies (Blind & Gauch, 2008). Some estimation even indicates that over 60% of all standards in the ICT sector are informal (Tapia, 2010). Yet, there is no common definition for an informal consortia and the consortia landscape has come to be very heterogeneous in characteristics such as technical issues, structure, members, transparency and intellectual property policies (Pohlmann, 2010). However, some informal standards are widely accepted and of great importance and even get an accreditation of a formal standard body. When it comes to the question of IPR, voting procedures are not always transparent and policies in informal standard consortia may allow strategies to push a patent in a standard. Furthermore informal consortia can function as a platform to lobby certain technologies which are protected by patents (Lemley, 2002).

Patent pools:

Another appearance of firms' consortia are patent pools, where companies come together and pool their patents to agree on a single license. Patent pools are a phenomenon that mostly appears in accompaniment of a standardized technology. Even though patent pools should solve the patent blocking problem and decrease coordination, there has been evidence in the literature that identifies incentives for firms to introduce their patents to a pool. Layne-Farrar et al. (2008) showed that pool participation is not automatic, whereas Baron & Delcamp (2010) gave evidence that earlier pool members are able to introduce more patents. Dequidt & Versaevel (2007) also identified a first mover advantage in being one of the initial pool founders and thus predict patent racing behavior. Baron & Pohlmann (2010) furthermore give empirical evidence, that the existence of a patent pool, increases patent declaration above an ordinary level.

R&D cooperation:

Cooperative arrangements may also accrue in an earlier stage of the innovation process, where companies come together to work on common R&D projects. Literature has shown that entities engage in R&D cooperation to pool common resources and thus gain more innovative output such as patents or products (Becker & Dietz, 2003). This paper solely focuses on R&D cooperation among essential patent owning companies to identify early collaboration that might influence the standard setting process.

The economics of tactic collusion:

We use the theoretical model of Ivaldi et al. (2003) on "the economics of tactic collusion" to better understand the effects of cooperative activities. Ivaldi et al. define "tactic collusion" as being not necessarily a collusion in a legal way, or collusion as a way of communication between parties. The term collusion only refers to the outcome of prices or quantities produced, that would arise under the existence of collusion or an official cartel.

We assume that collusion is only sustainable when firms expect sufficient future profits. In the context of this paper, we assume that future profits arise from the inclusion of a patent to a standard. The discount factor δ represents the weight firms put on future profits and only sustains when it is above a certain threshold.

For a homogenous product we construct the case when two firms produce the same good with the same unit variable cost c. Under price competition this would lead to $p = c$. Assuming these firms interact repeatedly, they may be able to gain a higher "collusive" price at $p^c > c$

and sharing the market to get half of π^c = $(p^c - c)D(p^c)$ each. Firms enter the tactic agreement because deviation from this price or production quantity would otherwise trigger a price war and end in $p = c$. Assuming that all firms have the same discount factor δ each would earn:

$$\frac{\pi^c}{2} + \delta \frac{\pi^c}{2} + \delta^2 \frac{\pi^c}{2} + \ldots = \frac{\pi^c}{2}(1 + \delta + \delta^2 + \ldots)$$

If in this situation one firm undercuts the other, it would get the whole market and thus receive a collusive profit of π^c. However, since a price war would eliminate any future profit, each firm sticks to the collusive price if:

$$\frac{\pi^c}{2}(1 + \delta + \delta^2 + \ldots) \geq \pi^c + \delta \; x \; 0 \qquad (1)$$

and if:

$$\delta \geq \delta^* = \frac{1}{2} \qquad (2)$$

We thus assume that a firm sustains collusion as long as it has a certain discount factor δ. This discount factor represents the relevant industry or market characteristics and needs to be above a certain threshold, here represented by $\delta^* = \frac{1}{2}$. In our case we assume that the threshold is represented by the marginal number of patents declared to a standard. Up until a certain threshold it is thus profitable to introduce another patent to a standard.

Ivaldi et al. identify several relevant factors for collusion. To analyze the influence from cooperative activities of informal standards consortia or patent pools, we use the "frequent interaction" model. The assumption is straight forward and states that firms find it easier to sustain collusion when they interact more frequently. This is due to their ability to react more quickly to deviations of others. We therefore construct the same setup and further assume that firms interact only every *T* periods. A more frequent interaction would mean smaller waiting periods *T*. Again collusion is sustainable if:

$$\frac{\pi^c}{2}(1 + \delta + \delta^2 + \ldots) \geq \pi^c + \delta \; x \; 0 \qquad (3)$$

and if:

$$\delta \geq \delta^* = \frac{1}{2^{1/T}} \qquad (4)$$

In this interaction model the critical threshold increases with *T:* When firms interact more often (decrease of *T*) the threshold decreases and collusion is easier to sustain.

We can therefore conclude for our case that an increase of membership in informal standards consortia or patent pools increases interaction with competitors. The increase of interaction decreases the periods between interaction *T* and thus makes it easier to sustain collusion by a decrease of the threshold $\delta*$:

$$\frac{1}{2^{1/T\downarrow}}\downarrow\ = \delta*\downarrow \tag{5}$$

This means that increasing interaction (in our example the increase of membership in informal standards consortia, patent pools or R&D cooperation) would decrease the threshold of the weight companies put on future profits. We assumed the threshold in our example to be the marginal number of patents included in a standard. Since we now face a lower threshold, we conclude that companies are able to include more patents in a standard while sustaining collusion. We can thus derive the following hypothesis from theoretical implications:

H2a: Firms which are active in informal standards consortia tend to declare more patents on standards!

H2b: Firms which are licensors of patent pools tend to declare more patents on standards!

H2c: Companies involved in R&D cooperation among essential patent owning companies tend to declare more patents on standards!

METHODOLOGY AND DATABASE

We assembled a very comprehensive database to test our hypothesis and control for external effects. To receive data about standard related patents, we obtained over 64,000 patent declaration statements of all major formal standard setting organizations such as ISO, IEC, JTC1 – a joint committee of ISO and IEC – CEN/CENELEC, ITU-T, ITU-R, ETSI, and IEEE. Over 800 disclosing entities could be distinctly identified. We only used the top 250 corporations for our analysis, which together declare over 96% of all essential patents. Since we have information about the timing of declaration, firm level data was used to construct a panel by one year units over ten periods from 2000 to 2009. The restriction of time periods and sample of companies thus reduces the number of analyzed patent declarations to 60,000.

Using the "Thomson One Banker" database, companies were informed by sales per year, employees per year, R&D expenditure per year, such as industry SIC code and country of origin. The database also included an extended description of the firms' business model, which could be used to distinctly identify firms' vertical integration to differentiate between manufacturing and non-producing entities. Furthermore the Thomson database of strategic alliances revealed 2134 R&D co-operations over 10 years among the 250 companies of sample.

To control the patent filing behavior of each company, a panel was constructed that counted all patent filings per company and year, using the website of the European Patent Office. The patent file search was restricted to only standard relevant IPC (international patent classification) classes. To distinctly identify these classes all patent numbers of the respective patent declarations were extracted and matched to the concerning IPC.

To gain information about informal standards consortia, we obtained all CEN surveys of ICT standards consortia from 1998 until 2009. We matched the standards consortia with the formal standards of the sample using the ICS (International Classification of Standards). In addition an in-depth internet research revealed over 34.000 consortia memberships over ten years. We furthermore identified 45 patent pools which can be related to a formal standard and discovered 69 licensors and 2847 licensees. To gather information about the past ten years, we used the search engine of www.archive.org. Memberships of informal consortia and patent pools were then matched to the 250 companies of the sample.

Table 1 gives a first overview on the industry sectors of essential patent owning companies. Especially large companies operate not only in a single sector; therefore data analysis only includes primary sectors. Companies were matched to a four digit SIC (Standard Industrial Classification) code, which was established to distinctly categorize industries. Table 1 solely displays two and three digit codes to get a broader picture. However, the results display a concentration on certain industries, where most companies (36.6%) operate in the electrical and electronic equipment sector (SIC code 36). The concentration is even higher when the results are weighted by the number of patent declarations per company and yield to a share of more than 70% in the sectors of communication equipment (336) and electronic components (367).

Table 1: Essential patent owning companies by industry SIC code

SIC code: industry sector	number of companies	share	weighted by patent declaration
35: Industrial Machinery & Equipment	10	4.59%	3.08%
38: Instruments & Related Products	12	5.50%	3.30%
48: Communications	24	11.01%	5.22%
365: Household Audio & Video Equipment	17	7.80%	7.90%
366: Communication Equipment	31	14.22%	42.31%
367: Electronic Components and Accessories	34	15.60%	31.12%
737: Computer & Data Processing Services	28	12.84%	5.14%
Others	62	28.44%	1.93%

The explained variable of our data base is patent declaration, which is a statement of a company to own patents that are essential to a certain standard. This statement is not mandatory and in some cases is made after a standard had already been released. Patent disclosures on the other hand are obligatory and in most cases not public and a more vague statement ex ante to standardization activities. We assume that in most cases companies disclose patents at a very early stage of standardization and declare when the agreed technology becomes more distinct. Almost half the declarations in our database do not indicate the patent number. We still matched the declared patent numbers to their patent families and solely identified 7318 essential patents. One patent can be declared as being essential to several standards. The number of patent declarations is therefore by far higher than the number of essential patents.

Table 2 displays the distribution of variables in the data panel. When comparing the mean and quartile numbers of essential patents and declarations, it is noticeable that we can evidence a strong concentration of patents owned by just a small number of companies. A closer look reveals that the top twenty essential patent owning companies already sum nearly 90% of all patents. This result is similar when we only regard patent families (85%) for the top twenty companies (Appendix 5). Variables such as the number of employees, average amount of sales and R&D expenditure, seem to be more balanced among the companies of the sample. Nevertheless comparing sales and R&D expenditure assumes a considerably high R&D intensity and indicates that most essential patent owning companies can be categorized to operate in high tech industries.

Table 2: Description of the database

	Observations	Mean	Standard Deviation	Min	Max
patent declaration	251	242.494	1401.07	1	14472
consortia memberships	248	8.612903	11.04771	0	50
pool licensor seats	251	.6294821	1.822681	0	11
pool licensee contracts	251	3.051793	9.449725	0	92
R&D expenditure	195	720.3453	1278.851	.067105	6194.7
employees	209	38088.98	70696	10	435160
sales	207	12452.49	22754.71	.0883615	157914.1
manufacturer	251	.7290837	.445321	0	1
non-practicing entity	251	.0517928	.2220513	0	1
related patent files	251	2338.024	6195.606	0	42127

DESCRIPTIVE RESULTS

To receive hints about our first hypothesis, that non-practicing companies tend to declare more patents on formal standards, we conducted simple descriptive analysis. Table 3 gives a vivid picture of the firms' business models. Three quarters of the companies are manufacturers and only slightly more than 6% are non-practicing. When we weight the results by the number of declared patents, the picture turns and reveals that almost 40% of all essential patents come from non-producers. These results already indicate a strong concentration of patents toward non-producing entities; nevertheless we need to isolate this effect in a regression to better control for external determinants.

Table 3: Essential patent owning companies by business model

business model	number of companies	share	weighted by patent declaration
manufacturer	183	75.31%	56.86%
provider	45	18.52%	4.89%
non-practicing	13	5.35%	38.05%
non-researching	2	0.82%	0.21%

Within the sample of non-practicing entities we differentiated between innovating and non-innovating firms. The results already display that the letter group seems to be of no great relevance concerning the research goal of this paper.

We run a first correlation analysis to test the coherence of patent declaration and memberships in informal consortia, patent pools and R&D cooperation among essential patent owning companies. The results are yet vague and only the correlation of declared patents and standards consortia and the business model non-practicing seem to have a positive linier connection. Our control variable of R&D expenses also shows a positive correlation, where firms that invest more also declare more patents. Correlation coefficients of all patent files that are in the ICT standard relevant IPC classes seem to be strongly positive associated with all three kinds of firm cooperation (membership seats). All of the other correlation coefficients are in the expected direction. To better answer our hypothesis, we need to use a non linear regression estimator.

Table 4: Correlation matrix (significance level in brackets)

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1)	patent declaration	1.00								
(2)	consortia memberships	0.29 (***)	1.00							
(3)	pool licensor seats	0.08	0.45 (***)	1.00						
(4)	pool licensee contracts	0.05	0.49 (***)	0.60 (***)	1.00					
(5)	R&D expenditure	0.25 (***)	0.75 (***)	0.41 (***)	0.37 (***)	1.00				
(6)	employees	0.07	0.54 (***)	0.45 (***)	0.32 (***)	0.75 (***)	1.00			
(7)	R&D Cooperations	0.17 (**)	0.74 (***)	0.44 (***)	0.49 (***)	0.66 (***)	0.52 (***)	1.00		
(8)	manufacturer	-0.06	0.14 (**)	0.01 (***)	0.12 (*)	0.18 (**)	0.07	0.16 (**)	1.00	
(9)	non-practicing entity	0.25 (***)	-0.08	-0.06 (***)	-0.07	-0.09	-0.10	-0.05	-0.38 (***)	1.00
(10)	related patent files	0.11 (*)	0.61 (***)	0.57 (***)	0.60 (***)	0.58 (***)	0.52 (***)	0.68 (***)	0.13	-0.07

TESTING THE HYPOTHESIS

The goal of our econometric analysis is to isolate the effects of firm's cooperative activities on the number of declared patents. We therefore test our explained variable to the aggregated firm data over the last ten years. We run a cross section regression and use the cumulative amount of patent declaration as our explained variable.

$$n_F = \alpha C_F + \beta P_F + \gamma L_F + \delta RC_F + \eta E_F + \zeta S_F + \theta RE_F + \iota B_F + \varepsilon$$

Where n_F is the number of patent declarations per firm, C is the number of consortia memberships, P is the number of pool licensor seats, L is the number of licensee contracts, RC is the number of R&D cooperation among essential patent owning companies, E is the average number of employees, S is the average amount of sales, RE is the average amount of R&D expenditure, B is a dummy variable for the firms' business model and ε is an idiosyncratic error term.

We use our count data of memberships in informal standards consortia per company. Our database of patent pools divides companies into licensors and licensees and we include the total count of matches to our sample of 250 essential patent owning companies. The total number of R&D cooperation among the sample companies is also counted to the total value per company. In addition companies are informed by the average number of employees, average amount of sales and average R&D expenditure over the last ten years. We use dummy variables for the business models: manufacturer and non-practicing entities. To control for different industry groups, we created control dummies for the sector SIC codes. To control for the different IPR policies in standardization, we created control dummies for the standard bodies. Our data is over dispersed since the variance of our explained variable is much larger than the mean. Therefore we choose the negative binomial regression estimator. Since not all companies are completely informed by our variables, the number of observations decreases from the initial sample.

Results from table 5 already give evidence for our hypothesis. Companies that are active in a higher number of informal standards consortia tend to declare more patents on standards. Since we control for all firm specific characteristics such as size or R&D activities, we can conclude that a high number of member seats in informal standardization has a positive influence on negotiations for including essential patents into standards. Especially in cases, where firms meet at an early stage in informal consortia to discuss about technologies that might later be transferred to the formal standard level, the results seem very plausible.

Literature confirms the role of standards consortia to be a platform to pre select technologies (Lemley, 2002).

A firms' connection to patent pools reveals a clear picture. Licensors tend to push more patents in standards, whereas licensees hemp this effect. Argumentation is straight forward, since licensors gain more royalty fees when more patents are included, in contrast licensees pay higher licenses when more patents affect a standard. Since licensees are companies that implement the standard to their products or components, these firms are active manufacturers and results also underline our prediction that vertically integrated firms have no incentive to increase the number of declared patents.

Earlier research already revealed the effect of patent pools and pool members on patent declaration. Baron & Delcamp (2010), find evidence that initial pool members are able to include patents of lower quality. Patents of pool insiders might thus be easier to include in a standard. Our findings underline this effect and give evidence that a high number of membership seats in a patent pool enables a firm to declare a higher number of patents to be essential for the standard.

Table 5: cross section negative binomial regression of patent declaration

cross section negative binomial regression of
patent declaration
observations = 194
log pseudolikelihood = -152.49351

explanatory variable	coefficient	robust standard error	z statistics
consortia memberships	.0792484**	.0267262	2.97
pool licensor seats	.3096713***	.0728021	4.25
pool licensee contracts	-.0296707***	.0090966	-3.26
R&D cooperation	-.0016325	.0048352	-0.34
employees	-9.52e-06	5.08e-06	-1.88
sales	.0000153	.0000245	0.62
R&D expenditure	.0008123***	.0002401	3.38
manufacturer	-.2083946	.3003302	-0.69
non-practicing entity	2.953047***	.9078268	3.25
cons	2.054246	.2787407	7.37

* represents the level of significance: * = 10%-level; ** = 5%-level; *** = 1%-level
note: control variables for industry SIC code and standard body are not displayed in the results

As predicted from the descriptive results, non-practicing entities tend to declare more essential patents, when controlling for firm size, R&D expenditure and industry sector. The comparison of the level of coefficients reveals the vertical integration as the strongest effect.

It seems to be crucial if the company will not only license out its patents, but also use the standardized technology for downstream products or not. When companies only want to license out, cooperative activities are of minor importance to declare an incremental higher number of essential patents.

Since the variable of patent declaration counts for every standard and also contains empty declaration we consolidate the patent numbers to the patent family. To test robustness we use this variable as our explained variable in a cross section regression (results in appendix 1). Even without considering empty patent declarations and not counting the number of standards one patent is affecting, our results stay robust in the level of significance and in algebraic sign. Descriptive results and the description of the database have shown that a little number of companies have a very high share of patent declarations. Data might thus be strongly skewed. To control for a possible bias, we logged our explained variable, but results remain robust (results in appendix 2).

Being a pool licensor might be an endogenous variable, since it is possible that the number of a firm's declared patents could influence the pool memberships. We therefore test if the explained variable patent declaration has a significant impact on being a pool licensor (results in appendix 3). The regression to explain pool licensor seats reveals no significant impact from patent declarations and we can therefore assume that the number of pool licensor seats is exogenous for our regression.

Several econometric tests confirm our findings and we believe that our results are robust to clearly identify the driving factors of patent declarations over the last ten years. Since we also want to test how the timing of cooperative activities influences the patent declaration behavior, we construct a data panel.

$$n_{F,Y} = \alpha C_{F,Y} + \beta P_{F,Y} + \gamma L_{F,Y} + \delta RC_{F,Y} + \eta E_{F,Y} + \zeta S_{F,Y} + \theta RE_{F,Y+2} + \iota B_D + \mathrm{K} T_{F,Y+2} + \varepsilon$$

Where $n_{F,Y}$ is the number of declarations per firm per year, C is the number of consortia memberships per firm and per year, P is the number of pool licensor seats per firm and per year, L is the number of licensee contracts per firm and per year, RC is the number of R&D cooperation among essential patent owning companies per firm and per year, E number of employees per firm and per year, S is the amount of sales per firm and per year, RE is the amount of R&D expenditure per firm and per lagged year, B is a dummy variable for the firms' business model, T is the number of standard relevant patent files per firm and per lagged year and ε is an idiosyncratic error term.

Firm's business models such as sector and standard body controls remain as dummy variables, but all other variables are informed in time series. In addition we use our variable of patent intensity to control for standard relevant patent filing behavior. We furthermore lag the variable of R&D expenditure and patent filing intensity for two years. The latter variable is lagged to consider the time between patent file and declaration to a standard. R&D expenditure is lagged to consider the delayed impact of investment.

The panel regression results from table 6 display the influence of cooperative arrangements on patent declaration. We are now able to even better control for the dynamic development of companies' size, investment of R&D such as the behavior of patent filing. Engagement in standards consortia as well as patent pools still favors the inclusion of patents to a standard. We can even be more precise and show that the effect of patent pools is slightly higher compared to the consortia effect. Thus an increase of the number of seats in patent pools and standards consortia enable a firm to declare more patents on standards.

Table 6: panel random / fixed effect negative binomial regression of patent declaration

	panel negative binomial regression of **patent declaration**	
	random effects observations = 1273 groups =189 log p_likelihood = -1958.5588	**fixed effects** observations = 962 groups =132 log p_likelihood = -1433.3896
explanatory variable	coefficient	coefficient
consortia memberships	.0392604***	.0327342***
pool licensor seats	.0585091*	.0105749*
pool licensee contracts	- .0021301	-9.46e-06
R&D cooperation	-.0025380*	-.0024318*
employees	-1.59e-06	-3.61e-07
sales	-2.43e-06	-2.29e-06
lag_R&D expenditure	.0002454***	.0002058***
manufacturer	-.3836486*	-.3426195
non-practicing entity	.2810799	.2859261
lag_patent filing intensity	.2230692	.0000162*
Cons	2.054246	-2.127302
AIC	3716.032	2491.02
BIC	3857.532	2543.256

* represents the level of significance: * = 10%-level; ** = 5%-level; *** = 1%-level
note: control variables for industry SIC code and standard body are not displayed in the results, variables tagged with lag_ are lagged by two years

The variable of R&D cooperation now displays a significant effect: Companies that engage in more cooperation to work on a joint R&D project are less likely to include possible patents in a standard. However, the effect seems to be weaker than of activities in consortia or pools. The literature reveals, that R&D cooperation mainly tends to develop product related technologies or components of manufacturers. Literature furthermore gives evidence that firms, which focus on downstream markets, are less likely to include their patents into standards, but use them to block competitors (Blind et al., 2006). The model of tactic collusion assumes that a firm's goal is to include the patent to the standard. This might in the case of R&D cooperation not be the case and empirical finding are thus contrary.

We run a fixed and random effects analysis and conduct the Hausman test to choose between fixed or random effect analysis. Using a considerable number of control dummies the Hausman test suggests using fixed effects. Table 6 illustrates that the results also remain robust for the random effects model. For the fixed estimator we find a stronger significance for our patent intensity variable, which controls the patent filing behavior of all companies in the related technological fields (IPC).

Our explained variable is count data and shows a respectively high number of zeros (69.5%). The Voung test suggest to use zero inflated estimators, when the data has a high number of zeros. When running a poisson zero inflated estimator, all results remain robust and lower AIC and BIC values such as a higher log pseudolikelihood value, suggest a better fit for the negative binominal fixed effect estimator (results in appendix 4).

CONCLUSION AND IMPLICATIONS

Anticipatory to our *H1*, we assumed companies to have different patent declaration incentives, depending on their vertical integration. Therefore we distinguished between manufacturers and non-practitioners in our analysis. First results show that vertically integrated firms which pay licenses to patent pools hemp patent declaration to a standard. Further cross section analysis confirms *H1* and distinctly reveals that non-practicing entities tend to declare more patents to formal standards. We conclude that these companies are not interested in product markets and therefore only target to license and sell their IPR. Findings in the literature revealed that patents increase their value when they are included in a technological standard (Rysman & Simcoe, 2006). Our results therefore underline the incentive for non-practicing companies to push their patents in a formal standard. However, patents are only included into standards when they are relevant to the technology and therefore have to embody an innovative contribution. Economic literature even predicts a more innovative standard development, when non-practicing companies are involved

(Tarantino, 2010). Even though non-practicing companies may more likely cause hold up problems, technological contributions which improve standard development should always be accepted. However, our results show that excessive patenting is more likely for non-producers. Overdone patenting behavior should be banned by participating companies, standard bodies and especially by a distinct legal and political framework.

The assumption derived from hypothesis *H2a*, *H2b* and *H2c* was that firms which enter cooperative arrangements in the context of standard setting are able to better push their patents in a standard. Using the theoretical model of tactic collusion by Ivaldi et al., confirms our assumptions and suggests an increase of patent files, when cooperative activities increase. Literature gives evidence that informal standards consortia are platforms for selecting technologies in an early stage of standard development (Lemley, 2002). Furthermore consortia can function as a mechanism to previously negotiate the question of IPR (Baron & Pohlmann, 2010). In the case of the third generation partnership project (3GPP), Leiponen (2008) found empirical evidence that informal standards consortia help firms to influence the standards setting process. Our empirical results are conform to the literature and we are able to approve *H2a:* Companies that tend to engage in a higher number of informal standards consortia also tend to declare more patents to a standard.

We are also able to confirm *H2b* and find significant evidence that companies, being a licensor in patent pools, are able to declare a higher number of patents to a standard. This finding also underlines empirical results from economic literature about advantages for companies to pool their patents when they are early members of the patent pool (Versaevel & Dequidt, 2007; Baron & Delcamp, 2010).

Our results indicate that engagement in consortia and pools previous to, or also accompanying formal standardization, help to negotiate and lobby an inclusion of patents to a standard. However, we do not interpret these effects as collusive behavior, but still find evidence that the outcome, in our case excessive patenting, can be characterized as a collusive product. We hence suggest that standard bodies need to ensure transparent and fair procedures to decide which patents affect a standard and which technologies should be included. Especially to prevent patent thickets, we suggest that responsible authorities need to conduct better surveillance on excessive patent declaration.

Finally we disprove *H2c* and give evidence that R&D cooperation among essential patent owning companies hemps patent declaration to a standard. We interpret that firms which are active in standardization, but also engage in joint research projects with their peers, have no incentives to introduce patents to a standard. We rather conclude that these firms focus on innovative improvements for their products in relevant downstream markets. R&D cooperation may yield to patent output, but these patents tend not to be included in formal standards. These patents' function most likely, is to block competitors from imitation.

Empirical results have shown that firms' activities in cooperative arrangements significantly influence the negotiation whether a patent is included in a standard or not, but an even stronger effect can be found for the vertical integration of a firm.

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Appendix 1:

cross section negative binomial regression of
essential patents (as to families)
observations = 194
Log pseudolikelihood = -523.26166

explanatory variable	coefficient	robust standard error	z statistics
consortia memberships	.1028629***	.0199293	5.16
pool licensor seats	.1571911***	.0522948	3.01
pool licensee contracts	-.0529662***	.0109555	-4.83
R&D cooperation	-.006376*	.0034028	-1.87
employees	-1.52e-06	3.35e-06	-0.45
Sales	-6.46e-06	.0000109	-0.59
R&D expenditure	.0003456	.0002322	1.49
Manufacturer	-.4152073	.3548425	-1.17
non-practicing entity	3.408003***	.8868945	3.84
Cons	.9825376	.3507143	2.80

* represents the level of significance: * = 10%-level; ** = 5%-level; *** = 1%-level
note: control variables for industry SIC code and standard body are not displayed in the results

Appendix 2:

cross section OLS regression
(log of dependant variable, patent declaration)
observations = 194
R-squared = 0.6753

explanatory variable	coefficient	robust standard error	t statistics
consortia memberships	.0774563***	.0194555	3.98
pool licensor seats	.3771238***	.0797924	4.73
pool licensee contracts	-.0051426	.0141269	-0.36
R&D cooperation	-.002941	.0037639	-0.78
employees	-.0000106***	4.14e-06	-2.56
sales	.0000163	.0000134	1.21
R&D expenditure	.0005214***	.0001973	2.64
manufacturer	-.3105486	.3189624	-0.97
non-practicing entity	2.31591***	.7215037	3.21
standard related patent files	-.0000109	.0000279	-0.39
Cons	1.216048***	.3484013	3.49

* represents the level of significance: * = 10%-level; ** = 5%-level; *** = 1%-level
note: control variables for industry SIC code and standard body are not displayed in the results

Appendix 3:

cross section negative binomial regression of
pool licensor seats
observations = 194
Log pseudolikelihood = -732.61164

explanatory variable	coefficient	robust standard error	z statistics
patent declaration	.0000104	.0002084	0.05
R&D expenditure	-.000491	.0003085	-1.59
Employees	2.34e-08	6.46e-06	0.00
sales	.0000509**	.0000251	2.03
consortia memberships	.0803713***	.0311801	2.58
non-practicing entity	-17.9247	6499.484	-0.00
Manufacturer	.417863	.5804349	0.72
Cons	-2.543527	.5757086	-4.42

* represents the level of significance: * = 10%-level; ** = 5%-level; *** = 1%-level
note: control variables for industry SIC code and standard body are not displayed in the results

Appendix 4:

zero inflated poisson (clustered panel regression) of patent declaration

explanatory variable	coefficient	robust standard error
consortia memberships	.125153***	.0394078
pool licensor seats	.1784655**	.0808314
pool licensee contracts	-.0289945	.02094
R&D cooperation	-.0094838***	.0031219
employees	2.84e-06	5.23e-06
sales	-8.15e-06	.0000254
lag_R&D expenditure	.0002155	.0002818
manufacturer	-.7282267	1.112814
non-practicing entity	1.363136	.9849965
lag_patent filing intensity	2.04e-06**	1.01e-06
Cons	-2.477497	1.888526
AIC	*102014.1*	
BIC	*102130.3*	
observations	*1157*	
groups	*162*	
Log pseudolikelihood	*-50984.05*	
Inflated: patent declaration (69.5% zeros)		

* represents the level of significance: * = 10%-level; ** = 5%-level; *** = 1%-level
note: control variables for industry SIC code and standard body are not displayed in the results, variables tagged with lag_ are lagged by two years

Appendix 5:

variable	essential patents (as to family)	patent declarations (statement)	employees	average sales per year	average R&D expenditure per year
period	2000-2009	2000-2009	in 2009	2000-2009	2000-2009
unit	count	count	count	million USD	million USD
mean	28	242	38089	12,452.489	720.345
median	1	7	6850	2,069.998	182.374
quartile alpha = 20%	0	3	671	180.879	23.801
quartile alpha = 40%	0	5	4113	965.546	97.522
quartile alpha = 60%	2	12	17491	5,077.114	323.772
quartile alpha = 80%	10	45	52203	16,489.392	902.787