CERNA WORKING PAPER SERIES

Patent Pools and Patent Inflation

The effects of patent pools on the number of essential patents in standards

Justus Baron & Tim Pohlmann

Working Paper 2010-13

Cerna, Centre d'économie industrielle
MINES ParisTech
60, boulevard Saint Michel
75272 Paris Cedex 06 – France
Tél. : 33 (1) 40 51 90 00

January 2011

Patent Pools and Patent Inflation

The effects of patent pools on the number of essential patents in standards

Justus BARON[1] **Tim POHLMANN[2]**

ABSTRACT

This article provides empirical evidence that patent pools contribute to the patent inflation around technological standards. Building upon theoretical propositions drawn from Dequiedt and Versaevel (2007) and a database of 64.619 declarations of essential patents to major international Standard Developing Organizations (SDO), we investigate how patent pools influence the number of patents on a standard over time. While the high number of patents in ICT technologies is increasingly recognized as hampering the implementation of standards, this is the first thorough empirical analysis of the driving factors of this patent inflation. We control for a wide array of factors relating to standardization and the technological field to isolate the incremental effect of patent pools. We find that patent pools increase the number of essential patents especially through patent races in view of patent pool creation. To a lower extent, we also find evidence for opportunistic patent introductions into existing patent pools.

KEYWORDS: patent pool, technological standard, patent race, patent thicket

JEL L13 L24 O34

[1] Cerna, Centre d'économie industrielle. MINES ParisTech, 60 Boulevard Saint Michel, 75272 Paris Cedex 06 – France, Tel. : 33 (1) 40 51 90 00, E-Mail: justus.baron@ensmp.fr.

[2] Berlin University of Technology, Chair of Innovation Economics, D-10623 Berlin Germany, Müller-Breslau-Straße VWS 2, Tel: +49 (0) 30 314 76624, E-Mail: tim.pohlmann@tu-berlin.de.

INTRODUCTION

Over the last ten years, the increasing number of patents declared essential to technological standards has attracted wide attention in the academic literature and among policy makers. A patent is called essential for a standard when it is necessarily infringed by any implementation of the standard. The fact that standards incorporate an increasing number of such essential patents is partly due to the fact that standards are technologically more complex and depend upon sophisticated inventions developed in costly firm R&D. Nevertheless, an important reason for the high number of essential patents is that inclusion into a standard may increase the commercial value of a patent for its holder (Rysman and Simcoe, 2009, Bekkers et al. 2001). Standardization thus generates additional incentives for firms to file more patents of lower significance (Layne-Farrar, 2008), or to adjust their patent files to ongoing standardization (Koehler et al., 2010).

As the patent inflation around standardization is a challenge for standard development and implementation, standardizing firms have come up with mechanisms to coordinate their strategies with respect to Intellectual Property Rights (IPR). Patent pools are probably the most important of these mechanisms accompanying formal standardization. Pools combine IPR to be licensed under a single contract. This increases transparency in technological overlapping fields, reduces coordination costs and avoids costly infringement litigation (Lerner & Tirole, 2004). As to Shapiro (2001), patent pools are the "purest solution" to overcome the intellectual property bottleneck.

Nevertheless, the redistribution of royalty income collected by patent pools is a contentious issue. Most pools redistribute royalties according to the shares of patents held by the various pool members. Such royalty distribution schemes could further exacerbate the incentives of firms to file many standard-related patents (Layne-Farrar & Lerner, 2010, Baron & Delcamp, 2010). Simcoe (2006) suggests that patent pools may induce especially small firms to declare more essential patents, as pools improve their chances of capturing value from standard related technology without having to enter into disadvantageous cross-licensing agreements. While the theoretical literature predicts that patent pools thereby increase incentives to invest in R&D (Gilbert, 2004; Lerner & Tirole, 2004), findings in the scarce empirical literature rather point to a higher propensity to file patents on an unchanged number of inventions

(Lampe & Moser, 2009). Therefore patent pools could themselves lead to opportunistic patent files and contribute to the patent thicket they are initially designed to clear. We will provide empirical evidence for this hypothesis using a comprehensive database of contemporary patent pools, three instrumental variables for pool creation and a wide range of control variables relating to standardization and the technological field.

In spite of the importance of essential patents for standard setting, there has been so far little research on the factors that are driving the increasing number of patent declarations. Building upon a theoretical framework proposed by Dequiedt and Versaevel (2007), we derive empirical predictions on the impact of patent pools on the number and on the timing of patent declarations. We predict that 1) standards for which essential patents are licensed through patent pools are characterized by a higher number of patents, that 2) the incremental number of patent declarations induced by the pool takes place during a race in view of the creation of the pool, and that 3) there is a lower impact of patent pools on the number of patent declarations once the pool is launched, but still higher compared to standards without a patent pool.

We test these hypotheses against a database of 64.619 patent declarations and 1.400 standards and technical specifications. We analyze the impact of patent pools on the number of patent declarations, controlling for the technological characteristics and the size of the standard. Using a set of instrumental variables that are independent of the commercial value of the standard or of the number of firms, we find a significant impact of patent pools on the number of patent declarations.

We then analyze the impact of patent pools on the timing of patent declarations with respect to standardization. We therefore observe standardization activity on the technical specifications in our sample over the last 18 years. We furthermore control for explanatory factors relating to the broader technological sector such as innovation shocks or institutional changes. This is done by identifying for each standard or specification the patent files in the potentially relevant technological field. Thus controlling for the external effects of standardization activity and changes in the related field, we find strong evidence for patent races in the wake of patent pool creation. Nevertheless, and in contradiction with the model of Dequiedt and Versaevel (2007), the impact of the patent pool on the number of patent declarations remains positive and significant well after the launch of the pool. We find evidence that this incremental effect is not due to a long term increase in innovation on the standard. Rather, patent pools seem to encourage opportunistic patent declarations that are disconnected from standardization activity and innovation in the related technological field.

The remainder of this article is organized as follows: Section 1 describes the theoretical framework and derives empirical research hypotheses. Section 2 outlines our methodology and describes the construction of the data set. Section 3 discusses descriptive results and in section 4 we tests the theoretical hypotheses through econometric analysis. Section 5 concludes the theoretical and empirical findings and derives policy implications.

THEORETICAL FRAMEWORK

Our predictions are based upon the theoretical framework developed in Dequiedt and Versaevel (2007). The starting point of this analysis is the assumption that the value of a patent is higher when it is included into a pool ($\bar{v}$) compared to when it is not included ($\underline{v}$) :

$\bar{v} > \underline{v}$.

Several empirical and theoretical investigations provide strong support for this assumption. Patent pools are seen as a potential solution to inefficiencies resulting from dense “thickets” of overlapping patents (Shapiro, 2001). For instance, patent pools avoid potential biases resulting from strategic behaviors and cognitive biases (Gilbert, 2004; Scotchmer, 2004; Colangelo, 2004). By bundling the licensing negotiations, patent pools reduce transaction costs and generate economies of scale. Inclusion into a pool furthermore provides a signal and generates an assumption that the patent is essential to the technology covered by the pool. Furthermore, pools can shield weak patents from invalidation claims (Choi, 2010) and facilitate patent enforcement (Delcamp, 2011). Delcamp (2010) finds empirical evidence that inclusion into a pool increases the value of a patent.

$\underline{v}$ is the value of a patent that is not included into a patent pool. This is not necessarily the same as the value of a patent when no patent pool exists. By reducing the number of patent holders licensing independently their technology, pools mitigate the multiple marginalization problem and increase the demand for licenses to use the patent. These benefits of pools accrue also to patents that are not included, but cover complementary technology. Patent holders therefore can benefit from pool creation even if they have no intention to join (Aoki &

Nagaoka, 2004; Brenner, 2009). These positive externalities of patent pools on other patent holders can be neglected as long as there are at least some advantages resulting from pool membership that are not shared with patents staying outside the pool.

In the Dequiedt and Versaevel model, *N* firms are running research programs, each investing an endogenous amount *x* in research. These firms are engaging into patent races on essential technology, when in each period only one patent can be filed. Research is a poisson process in which the probability of invention positively depends upon the level of investment *x*. The level of investment incurred by the participants to the race increases with the private value of a successful invention: $\frac{\Delta x}{\Delta v} > 0$. A particularly restrictive assumption of the Dequiedt and Versaevel model states that each firm can file only one patent and afterwards stops doing research. As the value of a patent is higher when included into a pool, everybody wants his patent to be included. Patents are granted and filed over time, and a the pool is already launched when only *K*<*N* of the patents are filed. *K* is thus the number of initial pool members and the number of inventions made until pool creation. The assumption that patent pools are created by early inventors before all participating firms have filed their patents is realistic. This feature is often neglected by the economic analysis of pool creation (Baron and Delcamp, 2010).

Patentees coming late *(N - K)* need to negotiate their entry into the pool. Dequiedt and Versaevel (2007) assume that patentees negotiating their entry have no bargaining power. They therefore have to pay an entry fee by shifting all the added value of including the patent into the pool to incumbent pool members. The value of a patent granted before *K* is therefore very different from a patent granted after *K*.

On the one hand, the initial *K* patents not only benefit from the direct beneficial effect of pooling the patent, but also from revenues of successive patents bargaining their entry. Therefore the value of an initial pool member patent is: $v_K = \frac{\overline{v}}{r} + \frac{N-K}{K}\frac{\underline{x}}{\underline{x}+r}\frac{\overline{v}-\underline{v}}{r}$.

The left hand side of the equation represents the value of a patent inlcuded into a pool $\frac{\overline{v}}{r}$, where *r* is a general discount factor. The prospective gains of pool membership are discounted by *r*, so that they are stronger incentives immediately before the pool creation than many years earlier. In addition to the usual discount factor, the increase in R&D efforts over time can be explained by maintenance fees and limited patent lifetime. Recent research reveals that patentees adjust their patent files to standardization (Köhler et al., 2010). Therefore delaying the filing of the patent allows observing the coverage of the standard with greater certainty. The second part represents the value added (entry fee) $\frac{\overline{v}-\underline{v}}{r}$ by the introduction of patens resulting from the research efforts of outsiders $\frac{(N-K)\underline{x}}{\underline{x}+r}$. These entry fees are divided among all initial pool patents *K*.

On the other hand, patentees obtaining their patent after *K* cannot expect any additional gain from the pool, as this added value is extracted from them at the time of entry (entry fee $\frac{\overline{v}-\underline{v}}{r}$). The value of the *N-K* late patents therefore falls to $\frac{\underline{v}}{r}$, the no-pool benchmark.

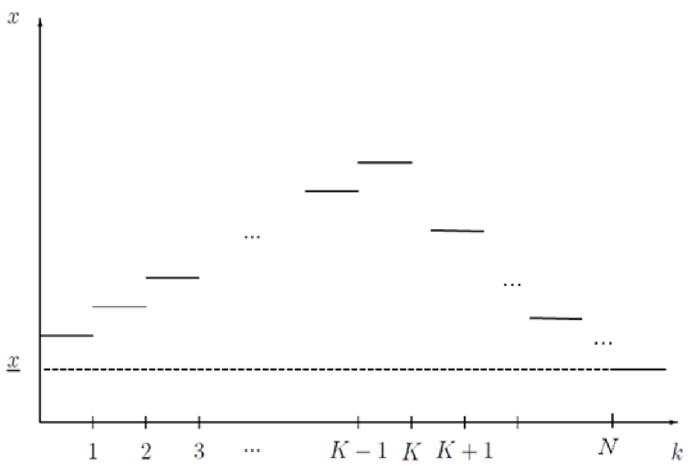
From this model, Dequiedt and Versaevel derive equilibrium patterns of R&D efforts *x*: for every k < K (until pool creation) $x_{k+1} > x_k > \underline{x}$; for every k > K (after pool creation), x_k = $\underline{x}$.. These patterns are straightforward. Before *K*, the prospective reward of pool membership and bargaining power with respect to successive entrants into the pool drives up the level of R&D efforts. The level of effort increases over time until K, so that the period immediately preceding pool creation is characterized by the highest level of R&D efforts. Along with the value of the patents, the level of R&D efforts made by remaining firms falls back to the benchmark $\underline{x}$ after pool creation in *K*.

As discussed, the Dequiedt and Versaevel model rests upon a particularly restrictive assumption: each firm can include only one patent into the pool. Dequiedt and Versaevel do not provide any justification for this important assumption. Baron and Delcamp (2010, 2011) describe patterns of patent pool growth that empirically contradict this theoretical hypothesis. In particular, they find that incumbent pool members account for the majority of patents introduced late into patent pools. Rather than withdrawing from R&D relevant to the pool, pool members file patents that are even more focused on the technology covered by the patent pool.

In order to increase its realism, we adjust the Dequiedt and Versaevel model by allowing firms to introduce more than once essential patents into the pool. The share of the pool's royalty revenue that a pool member i receives now depends upon the share s_i of pool patents it respectively owns. This assumption describes rather exactly the royalty sharing rules of contemporary patent pools as described by the empirical literature (Layne-Farrar and Lerner, 2010; Baron and Delcamp, 2011).

The value of the patents and hence R&D efforts still increase over time up to pool creation. After pool creation, the efforts of pool outsiders fall down to the no-pool benchmark, as they have to bargain entry into the pool. Pool insiders also have to bargain for introducing additional patents, but as they are pool members, they receive themselves their share of this entry fee. Pool insiders continue to invest more in R&D than in the no-pool benchmark case, and their incentives are proportional to their share in the pool. Baron & Delcamp (2010) provide support for this theory, as they show that a big majority of patents introduced at later stages into existing patent pools are owned by incumbent pool members. The resulting overall investment in R&D after pool creation is lower than before pool creation, as the expected patent value faced by outsiders is reduced to $\underline{v}$. Also the expected value faced by insiders decreases, as it is reduced to $\underline{v} + (v_k - \underline{v}) \times s_i$ (where $v_k = \frac{\overline{v}}{r} + \frac{N-k}{k}\frac{\underline{x}}{\underline{x}+r}\frac{\overline{v}-\underline{v}}{r}$ and s_i is the share of the firm in the *k* patents in the pool), but this is still higher than in the no-pool benchmark case. As *k* approaches *N* (the point when the pool coverage is complete), the expected benefit from future entry fees tends to zero, and v_k tends to $\frac{\overline{v}}{r}$. At *N*, the pool is completed, patent value falls to $\underline{v}$. The development of R&D efforts can thus be sketched as follows: for every *k*<*K* (until pool creation) $x_{k+1} > x_k > \underline{x}$; for every *N* > *k* > *K* (after pool creation), $x_{k-1} > x_k > \underline{x}$.

Figure 1: R&D investment in periods before and after pool creation



Adjusted graph in reference to Dequiedt and Versaevel (2007)

The predicted patterns of R&D efforts around the creation of a patent pool rest upon assumptions that are not overly restrictive in view of the existing empirical analysis of patent pools. Indeed, empirical evidence supports the assumptions that patent value increases when a patent is included into a pool, that pools are created when some, but not all essential patents are filed, and that incumbent pool members are allowed to include further patents and indeed stand for the majority of patents introduced late. However, there is no direct empirical evidence on the bargaining game between incumbent pool members and entrants. On the one hand, assuming full bargaining power for the incumbent pool members and monetary transfers of the added value from entrants to incumbents seems to be the most restrictive hypothesis of the theoretical analysis. On the other hand, Baron and Delcamp (2011) provide evidence that incumbent pool members can introduce patents of lower quality than outsiders entering the pool. Even without assuming full bargaining power, this empirical evidence corroborates the prediction of an advantage associated with being founding member of a pool. This advantage would generate the same type of patent races in view of pool creation as described in our simpler setting.

We will test the theoretical predictions of the effect of patent pools on firm investment in essential patents. We approximate the firm investment by the number of patents declared to be essential by their owners. Based upon this framework, we derive the following predictions:

H1: The existence of a patent pool, controlling for standardization and innovative shocks, increases the number of patents declared essential for a formal standard.

H2: The prospect of a pool creation increases the number of patents declared essential for a formal standard before a pool is formed.

H3: The number of patents declared essential for a formal standard decreases after pool creation, but is still higher than without the existence of a pool.

METHODOLOGY

We test the aforementioned hypotheses empirically using an extensive database including 1.400 standards and technical specifications observed over 18 years. Our analysis focuses on the major formal standard developing organizations (SDO) which operate on an international level: ISO, IEC, JTC1 – a joint committee of ISO and IEC – CEN/CENELEC, ITU-T, ITU-R, ETSI, and IEEE. This classification also finds support in several literature sources (Iversen, 2002; Leiponen, 2008; Blind & Gauch, 2008). As all these institutions practice the same IPR policy, we can rule out that institutional factors affect the comparability between standards in our sample.

The unit of analysis is the standard. Several versions of the same standard are thus not treated as different observations, especially because it is impossible to consistently identify the relevant standard version for each patent declaration. It is furthermore impossible to analyze ETSI jointly with the other SDOs. While all patent declarations to the remaining SDOs in our sample refer to formal technological standards, most patents declared to ETSI are essential Technical Specifications (TS). The PERINORM[3] database provides detailed bibliographic information on formal technological standards, but does not cover TS. We will thus proceed by analyzing ETSI and the other SDOs separately. In the case of ETSI, we use the TS, whereas in the case of the other SDOs we can rely upon the standard as normalized unit of analysis.

As our analysis focuses on the interplay between standards and patents, we only take into account standards for which at least one patent has been declared essential. A patent declaration is a public statement by a patent holder declaring that his patent is essential to a specific standard. These declarations are made publicly available on the website of the SDO. [4]

In We use all patent declarations made since 1992 to the SDOs which are stated above. More than 64.000 patent declarations were retrieved in March 2010 from the patent databases of the SDOs, where the declaring company has to state the formal standard identification number, the date of registration and the patents affected. We labeled each patent declared essential to each standard as one declaration. For example a patent declaration for two patents declared essential to two different standards is counted as four declarations. Empty or so-called blanket patent statements - i.e. statements of ownership of essential IPR that do not provide patent

[3] PERINORM is the world’s biggest database with bibliographic information on formal standards and is regularly updated by the SDOs DIN, BSI and AFNOR.

[4] Patent declarations must not be confused with patent disclosures. A disclosure is a statement to the respective working group or commission of the SDO in a very early stage of standardization, before any official documents are released. A declaration in comparison is a public statement to the SDO which can be recognized by everyone, not only by internal commissions or working groups. While a disclosure includes all technologies that might potentially become relevant to a standard, a declaration reflects a patent owner’s belief that his patent is essential to the standard as defined.

numbers - were also counted as one declaration. Counting separately individual patents that are declared together in one statement and taking into account blanket statements means that we have a “maximal interpretation” of the patent declaration databases. For this reason, our number of declarations is higher than the number of patents used in other research projects focusing on the same SDOs (Bekkers and Martinelli, 2010).

The count of IPR declarations is only an approximation of the valid patents that are essential for a standard. Firms declare IPR they believe to be essential, but no objective evaluation of this claim is made. It might therefore be the case that many of the declarations relate to patents that are not really essential to the standard. On the other hand, even though some SDOs oblige firms participating in standardization to declare their essential IPR, it cannot be guaranteed that all essential patents are accurately declared. This is not a limitation to our use of the variable. Indeed, we are interested in the driving factors of the patent inflation around technological standards. Therefore, we are interested in what determines a company’s decision to claim and declare ownership over components of a technological standard rather than what determines the grant and disclosure of valid essential patents.

We further identify 43 existing patent pools and 11 failed attempts to create a patent pool and match these pools to the standards in our sample. Pool administrator clearly display the technological standards that are covered by the patent pool license, and in most cases independent experts certify that all patents in the pool are essential for a specific technological standard.

We wish to identify a causal effect of patent pools on the number of patent declarations. It is therefore crucial to rule out endogeneity issues. Patent pools are more likely to be created for standards with many patents. Furthermore, the likelihood of a pool creation may also be correlated with the commercial relevance of the standard, which also drives upwards the number of patent declarations. We therefore use instrumental variables for the occurrence of a patent pool on a standard.

The occurrence of a patent pool is likely to be linked to several other explanatory factors than the number of relevant patents. First, some firms have specific policies with respect to patent pools. Some patent holders are very active in joining or even creating patent pools, others do not join such initiatives as a general rule. We expect that when the patent holders that are relevant for a specific standard are generally more inclined to join pools, the likelihood of pool creation increases. We measure this variable by counting the number of pools a patent holder is involved in, weighted by the number of standards for which he declares essential patents (pool_propensity). Second, patent pool creation is greatly facilitated by patent pool administrators. These administrators generally specialize on a specific technological field, and often cooperate with specific SDOs on a regular basis. Therefore the likelihood of pool creation is higher for standards issued by SDOs with a bigger number of patent pools in general. We therefore count the number of pools per SDO, weighted by the number of standards, excluding the standard of observation (pools_per_sdo). Finally, we expect that pool creation is more likely among firms knowing each other well. We capture this factor by counting how often two firms declaring patents on the observed standard have declared patents on the same standard in the whole sample, and we weight this count by the number of possible combinations resulting from the number of declaring firms (codeclaration_weighted).We test the validity of our instrumental variables using underidentification and Sargan tests on a linear regression. The three instrumental variables jointly explain more than half of the probability that for a given standard including essential patents there will be a patent pool, and the underidentification test rejects the hypothesis of weak instruments. The Sargan test indicates that they do not have a strong correlation with the explained variable that is not captured by the occurrence of a patent pool (see test statistics of Sargan's test in Appendix2).

We also wish to analyze the timing of patent declaration with respect to pool creation. We therefore identify for each pool its date of launch. In our analysis, the date of launch is defined as the date at which a patent pool administrator publishes a call for patents to gather holders of patents that are essential to a technological standard (Baron & Delcamp, 2010-1). Such a call is usually made upon the initiative of a group of patent holders wishing to create a pool. They then turn to a pool administrator in order to identify and federate the remaining patent holders and to steer negotiations on the concrete licensing provisions. In our analysis, the race in view of pool creation therefore takes place until the release of the official call for patents, so that companies joining the pool initiative after the call for patents or even after the licensing stage has begun are analyzed as latecomers facing a bargaining situation with a group of incumbent pool members.

A match of the different patent statements identified 732 TS from ETSI relating to 85 different projects and 667 distinct standards from the other SDOs, where some standards were accredited in more than one SDO. If that was the case, the SDO of first release was the selected reference. Appendix 1 provides an overview over the reference SDOs in our sample. As discussed, a different unit of analysis applies to ETSI. It is also apparent from Appendix 1 that ETSI stands for the vast majority of declarations in our database.

In order to control for standardization activity and standard size, we produce a set of control variables. We matched our sample of formal standards (excluding ETSI) to the database PERINORM, where we obtain information on standardization activities and characteristics such as standard release, version releases, standard amendments, technological class, document type or number of standard pages. The same technical information regarding ETSI TS is directly informed through the ETSI website. These data allow a description of the technological fields that are relevant for our analysis. 54% of the standards are classified in ICS class 33 (Telecommunications) and 35% in ICS class 35(Information technologies). ICT technologies (ICS classes 33, 35 and 37) jointly stand for almost 90% of the standards and 99.81% of the patent declarations in the database.

Building upon the declared essential patents, we identify for each standard a much more precise technological field. All patents are classified by patent examiners according to a very precise classification system, the International Patent Classification (IPC). At the most detailed level, patentable technology is divided into more than 70.000 IPC subclasses. We inform and count for each standard the IPC subclasses of the declared essential patents. We then compute weighting factors indicating how relevant each IPC subclass is for each particular standard. Proceeding this way, we find that out of 70.000 existing IPC subclasses, 1.400 subclasses are relevant for at least one standard. On the website of the European Patent Office, we inform worldwide patent files for every year from 1992 to 2009 for each of these subclasses. For every standard and every year, we multiply the weighting factors of the relevant classes with the worldwide patent files in the respective subclass. Thus we obtain a variable that indicates for every standard and every year the number of patent files in the relevant technological field.

Finally, the formal standards in our database are linked to informal industry alliances arising around standardization. Several consortia can directly be related to formal standardization projects. We use data from the 15 editions of the CEN survey of ICT consortia, identifying 453 informal consortia since 1998. Our consortia database thus only includes organizations that meet objective selection criteria[5]. Consortia are matched to formal standards using liaison statements. A liaison implies an accreditation and a cooperative standardization development between the formal and informal standards bodies. If an official liaison statement was not given, we conducted a more detailed analysis in order to identify the related standard. In total 45 different informal consortia could be related to 115 formal standards including essential patents.

We have thus produced a comprehensive database of formal technological standards including data on patent declarations, standardization activity, and patent files in the relevant technological field. We have produced three well performing instrumental variables for the occurrence of patent pools. All information is given in longitudinal data over 18 years. This broad database allows testing the impact of patent pools on the number and timing of patent declarations controlling for activities in standardization and exogenous technological shocks.

DESCRIPTIVE ANALYSIS

The following graph 2 shows the timing of patent declarations as measured by our declaration count with respect to the first release of the respective standard. Taking all declarations to the reference of the date of standard release, graph 2 illustrates the timing of declaration. 56% of all declarations are made later than one year after the first standard version is officially released. Slightly less than 35% of all declarations are stated before or in the year of the first standard release. In conformity with the results of Layne-Farrar (2010) on an analysis of ETSI patent declarations, we reveal that a significant share of declarations is made in a way that seems disconnected from the standardization process. However, patent declarations are in some cases connected to a later standard version or an amendment. Graph 2 displays the timing compared to the first standard version release, where in some cases other standard releases might follow. Therefore the standard might still change in its technical scope and newly included components could be affected by patent claims, which would not be relevant before.

[5] „The organization must be international in outlook and scope, not simply an instrument of single-nation policy, must have an active and international membership, must not be set-up specifically as a single vendor, government, or proprietary technology advocacy group and must be of importance to the areas of standardization or its processes" CEN/ISSS 2009, page 10.

Figure 2: Timing of patent declaration by the reference date of standard release

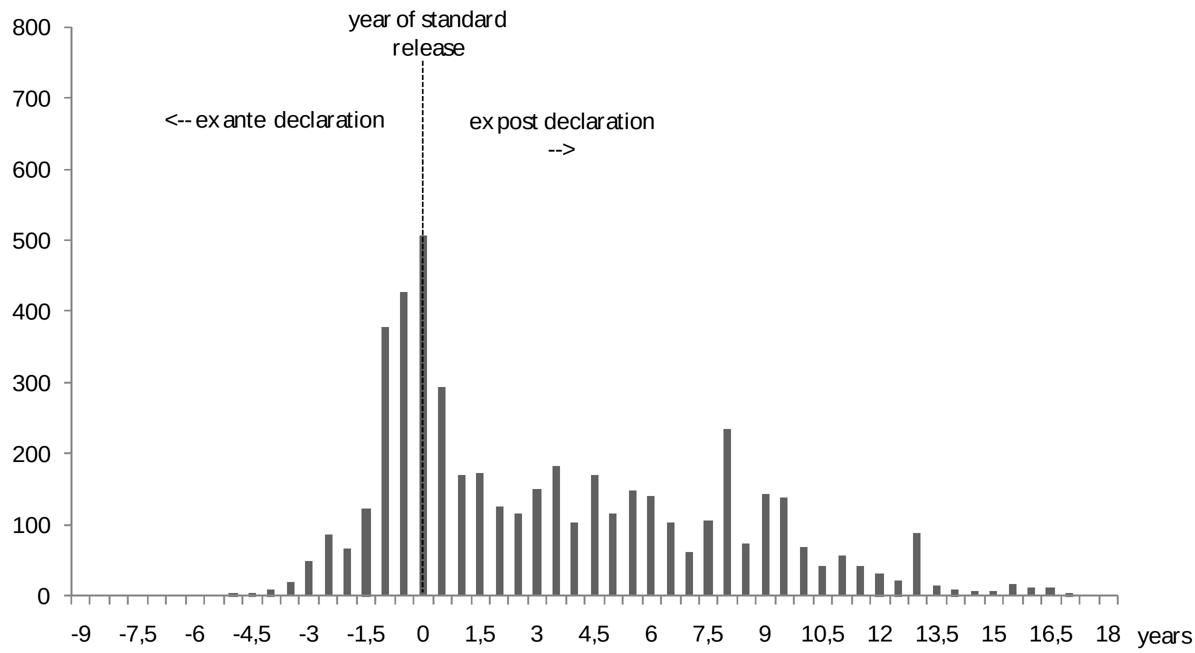


Table 3 displays the relationship of declarations to measures of the standard size and standardization activity such as number of pages, releases, version releases or amendments. We can evidence a size effect; the bigger a standard, the more patents are declared. The table furthermore indicates a positive relationship between patent declarations and standardization activities.

Table 1: By SDO and ETSI: correlation coefficient and coefficient of determination for declarations per standard to the sample variables

		Number Pages	Number Releases	Number Amendments
SDOs	correlation coefficient	0.32	0.16	0.44
SDOs	coefficient of determination	10.51%	2.43%	19.03%
ETSI	correlation coefficient	0.15	0.07	/
ETSI	coefficient of determination	2.33%	0.45%	/

Our first descriptive results of the declaration patterns already indicate that our declaration count is a meaningful measure of an economic reality that is closely linked to the timing and importance of a standardization project. Nevertheless, we also find evidence that the activity and the characteristics of a standard itself might not be the only factors that can influence a patent declaration. We were able to match the existence of informal standards consortia and patent pools to our panel of formal standards, to test external factors of declarations.

Table 4 clearly shows that standards that can be connected to a pool or an informal consortium have a much higher average number of declarations. These standards also have on average a higher number of pages, more releases and are more often amended. Furthermore, there seems to be a link between pools and consortia: indeed, out of 39 standards that can be linked to a pool, 31 can also be linked to a consortium (out of the 628 standards for which there is no pool, only 84 can be linked to a consortium).

Table 2: Median and Average number of declarations per standard

SDO Sample	Median	Mean	ETSI Sample	Median	Mean
all standards (excl. ETSI)	2	10.33	all ETSI standards	14	704.63
standards connected to a pool	27.5	51.14	ETSI standards connected to a pool	61	645.5
standards not connected to a pool	2	8.89	ETSI standards not connected to a pool	11	712.85
standards connected to a consortium	5	23.70	ETSI standards connected to a consortium	36.5	3261.17
standards not connected to a consortium	1	8.68	standards not connected to a consortium	11	266.37

Taking into account the positive correlation between standard consortia and patent pools as well as between both these instruments and the number of declarations, standardization activity and number of pages, the effect of consortia or pools on patent declarations cannot clearly be distinguished. Therefore econometric analysis is needed to control for all these factors that have been found to be relevant and to compare the evolution of the number of essential patents with the trend in the relevant technological field. Furthermore, panel analysis helps in getting clearer insights into the direction of causality.

TESTING THE HYPOTHESES

In a first step, we want to identify the effects of a patent pool on the number of patents declared essential for a standard. We thus test Hypothesis 1 against the cross section dataset of standards and technical specifications:

$$n_S = \alpha P_S + \beta C_S + \gamma S + \delta T_S + \varepsilon$$

Where n_s is the number of declarations per standard, P is a dummy variable for patent pools, C is a dummy variable for consortia, S and T are vectors of control variables on standard and technology characteristics and ε is an idiosyncratic error term.

As discussed, we use instrumental variables for the occurrence of patent pools. We include the number of releases, amendments and standard pages as independent variables to control for the scope of the standard and the intensity of standardization. We furthermore add a dummy variable giving 1 if there is a consortium that can be linked to this particular standard. As we have seen from the descriptive statistics, standards that can be related to a consortium have a much higher number of patents. We expect that part of this effect is captured by the scope and relevance of the underlying standard, but there are also arguments pointing to a causal relationship between consortia and patent declarations. As consortia might furthermore facilitate the launch of patent pools, it is important to control for consortia when examining the effects of patent pools on the number of patent declarations. In order to exclude truncation biases, we also control for the age of the standard and the square of this age. Furthermore, we control for SDO and ICS class effects.

As stated earlier we had reasons to separate the statistic estimation of the ETSI sample. The variable document type for the ETSI calculations controls for the different types of ETSI output. Furthermore the ETSI data do not report amendments.

Table 3: Cross Section instrumented poisson estimation of patent declaration:

	SDO sample (excluding ETSI)	**ETSI sample** (only ETSI)
	instrumented poisson Coefficient (Z statistic)	instrumented poisson Coefficient (Z statistic)
patent pool exists (instrumented)	17.99816*** (19.12)	17.09596*** (18.59)
consortium exists	.4110163 (1.31)	-.041494 (-0.09)
number of standard pages	.0192312** (2.14)	.0006457 (1.51)
number of standard releases	-.5093366*** (-2.79)	.0888959 (1.48)
number of standard amendments	-.0050489 (-0.07)	/
standard age	.0137983 (0.45)	.2052691*** (4.31)
standard age squared	-6.53e-06 (-0.26)	-.000182*** (-4.59)
Observations	462	608
R-squared	/	/

<u>instrumented:</u> patent pool exists

<u>instruments:</u> co-disclosure, pool experience, pools per SDO (only for SDO sample)

* represents the level of significance: * = 10%-level; ** = 5%-level; *** = 1%-level

<u>note:</u> control dummies for SDOs, technological standard classes (ICS) and standard document types are not displayed in the results

The econometric results confirm our descriptive findings. The existence of a pool has a positive and very significant effect on the number of declared patents. Through instrumental variable estimation and controlling for standard size and scope, we make sure that this finding reflects a causal relationship. Hypothesis 1 is therefore verified. To test robustness, we also run a non instrumented negative binominal estimator, where the results are consistent with our finding (Appendix3).

As suggested by our theoretical analysis, patent pools increase the incentives of participating firms to engage into R&D and to declare a high number of patents. From an optimistic point of view, the positive effect of patent pools on the number of patent declarations would indicate that patent pools are efficient in mitigating the adverse effects of patent thickets on innovation and induce supplementary innovation efforts. Nevertheless, as we find a higher number of patents holding constant indicators of standard size and standardization activity, this supplementary investment is at least partially reflected in a higher propensity to declare patents on standards at given technological content. This finding is in line with our theoretical framework, in which the additional investment in R&D does not add any value to the standard, and thus suggests that patent pools exacerbate socially wasteful excess investment in patent races. An analysis of the timing of patent declarations allows a more precise welfare analysis of the effects of patent pools on innovation and patenting incentives.

We therefore turn to panel data analysis. Our explained variable is still the number of declarations on a standard, but this time the observation is a one year time span for each standard (a half-year span in the ETSI sample).

$$n_{S,Y} = \alpha_i PC_{S,Y+3} + \alpha_{ii} PC_{S,Y+1} + \alpha_{iii} PC_{S,Y-1} + \alpha_{iv} PC_{S,Y-3} + \beta C + \gamma S + \delta T + \eta SY + \zeta TY + \theta Y + \varepsilon$$

Where $n_{S,Y}$ is the number of declarations per standard per year, $PC_{S,Y+3}$ to $PC_{S,Y-3}$ are dummy variables for the timing with respect to pool creation, C is a fixed dummy variable for consortia, S and T are fixed standard and technology characteristics, SY and TY are time variant standard and technology characteristics, Y is a year fixed effect, and ε is an idiosyncratic error term. In the fixed effect specification, C, S and T are replaced by a standard fixed effect.

Our main explanatory variables are dummies on the timing with respect to patent pool creation: $PC_{S,Y+3}$ gives one if a pool has been launched 3 or 4 years after this period, $PC_{S,Y+1}$ indicates whether a pool has been created 1 year or 2 years after this period, $PC_{S,Y-1}$ is 1 if a pool has been launched 1 year before this period or in the same year, and $PC_{S,Y-3}$ indicates pool creation 2 or 3 years before this period. According to hypothesis 2, we expect that $\alpha_{ii} > \alpha_i > 0$, reflecting a patent race around pool creation. According to hypothesis 3, $\alpha_{ii} > \alpha_{iii} > \alpha_{iv} > 0$. The effect of the pool on the number of patents after creation is lower than during the race before launch, but still positive and significant.

The control variables include characteristics of the standardization process varying over time, such as the number of amendments or of releases issued close in time to that moment, and the current number of pages of the standard. To control for the usual timing of patent declarations with respect to standard age, we introduce the age of the standard (time since first release) and its square. We further include time variant characteristics of the technological field, captured by the number of patent files in the field and its lag. All factors globally affecting patent intensity in a technological field should be reflected in this count. As time invariant control variables, we still use class, SDO controls and document type controls (dropped in fixed effect specification). We add a time fixed effect in particular to rule out truncation problems.

To address the problem of truncation, we furthermore drop observations for 2009 and 2010 (but all results hold the same if we keep them).

Table 4: Negative binomial fixed effect and zero inflated poisson estimation of patent declaration:

	SDO sample (excluding ETSI)		**ETSI sample** (only ETSI)	
	fixed effects neg. binominal coefficient (Z statistic)	Zero inflated poisson coefficient (Z statistic)	fixed effects neg. binominal coefficient (Z statistic)	Zero inflated poisson coefficient (Z statistic)
3-4 periods before pool launch	.5491762* (1.88)	.9396377* (1.79)	.6471473** (2.16)	-.4820434 (-0.96)
1-2 periods before pool launch	1.000787*** (4.57)	1.101902*** (3.90)	.808937*** (3.73)	-.3699642 (-0.92)
1-2 periods after pool launch	.8228852*** (3.86)	1.361709*** (4.98)	.9205096*** (3.18)	1.171171 (1.58)
3-4 periods after pool launch	.2199966 (0.89)	.7831278*** (2.93)	.506622 (1.20)	0.30 (0.766)
informal standards consortia exists	/	.349431*** (6.93)	/	-.1850134 (-0.75)
number of standard pages this period	/	.0014075*** (8.06)	.0017191*** (5.58)	.0011659 (1.01)
periods around standard release	.5765244*** (13.19)	.4904195** (2.47)	.2044051*** (3.13)	-.2531416* (-1.67)
period of standard amendment	.146327*** (3.07)	.1428508*** (2.84)	/	/
standard age	.1083803*** (11.22)	.0332867 (0.54)	.2256602*** (7.11)	-.0976848 (-1.66)
standard age square	-.0000959*** (-10.58)	-.0000302 (-0.56)	-.0002118*** (-7.39)	.0000877 (1.58)
patent filing intensity	3.06e-13 (1.41)	-3.57e-13 (-0.79)	-3.45e-13 (-0.77)	-1.01e-12 (-1.27)
lag patent filing intensity	3.41e-13* (1.68)	5.88e-13 (0.99)	3.04e-12*** (6.50)	3.57e-13 (0.39)
total declarations this period	.0013575*** (3.87)	.0010634* (1.90)	.0001145*** (10.10)	.0001683*** (6.31)
cons	-33.67874 (-13.17)	-10.50678 (-0.61)	-65.37303 (-7.49)	30.59822 (1.91)
observations	7735	8296	5567	17874
groups	455	488	383	526
log pseudolikelihood	-2824.0004	-1707.908	-4106.3113	-55550.01
AIC	5631.885	3459.816	8171.938	111180
BIC	5735.854	3595.548	8417.048	111491.7

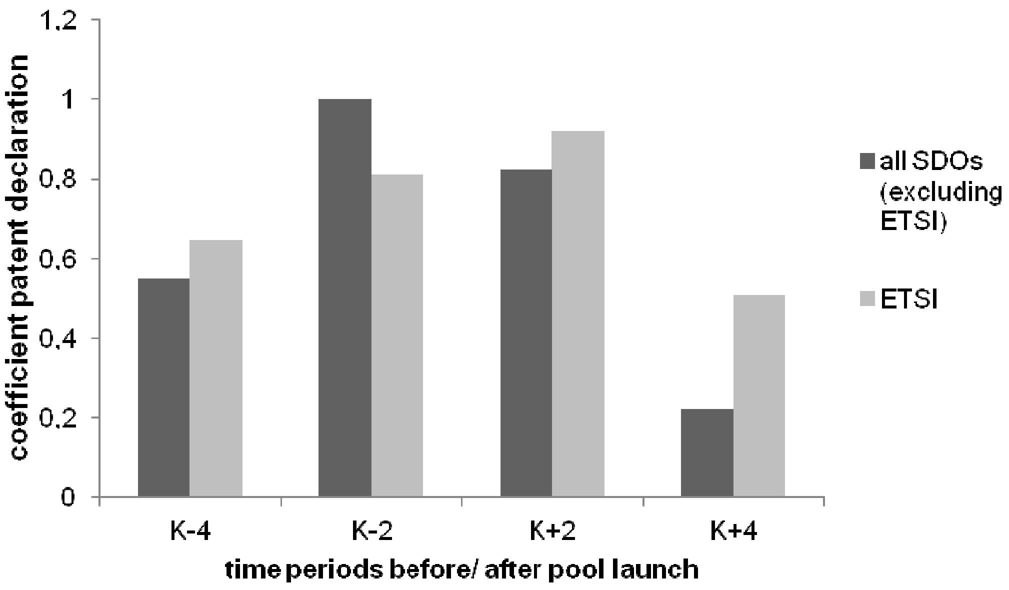
* represents the level of significance: * = 10%-level; ** = 5%-level; *** = 1%-level

note: control dummies for SDOs, technological standard classes (ICS) and standard document types are not displayed in the results

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. In order to ensure that we really control for all unobserved heterogeneity, we report results from a fixed effect estimation, where all time invariant effects have been replaced by standard fixed effects. We also run a random effects analysis and conduct the Hausman test, which suggests to use the fixed effects estimator. However, even though the negative binominal estimator has the best goodness-of-fit, this fixed effects estimator does not fully control for individual fixed effects (Guimarães, 2007). As suggested from the econometric literature we also run a fixed effects poisson estimator, but our results stay robust (Appendix4). The explained variable of counted patent declarations shows an excessive number of zeros in both samples. For the SDO sample we can identify 7796 zeros out of 8296 observations and 16265 zeros out of 17874 for the ETSI sample. These are 93.98% and 90.99% zeros respectively. For zero inflated count data, the Vuong test (Vuong, 1989) suggest to use zero inflated models. We therefore run a zero inflated poisson estimator. We also display the goodness-of-fit statistics using the pseudolikelihood values as well as the Akaike Criterion (AIC) and the Baysian Information Criterion (BIC). For the SDO sample the values suggest to use the zero inflated model since the pseudolikelihood is higher and the AIC and the BIC values are lower. However, for the ETSI sample the values suggest to use the negative binominal fixed effect estimator.

We can infer from the results that patent pools have a very significant impact not only on the overall number, but also on the timing of patent declarations. The following chart shows the coefficients on the timing with respect to pool creation in a graphical way. Especially in the periods before the pool launch is officially announced, we find evidence for a patent race and thus validate Hypothesis 2. The hypothesis of patent races in view of patent pool creation is corroborated by the analysis of failed attempts of pool creation. If pools increased the number of patent declarations by reducing inefficiencies in the licensing process, we would expect failed pools to have no effects on the number of patent declarations. To the opposite, we find that pool launches that eventually fail exhibit an even stronger increase in patent declarations around the date of official announcement of a pool launch.

Figure 3: Coefficients on timing with respect to pool *launch*



We can compare our findings to the theoretical predictions from Dequiedt and Versaevel (2007). The model is overall verified, but we notice a significant difference between our findings and the model. Patent declarations remain on a high level several years after the peak, and Hypothesis 3 is therefore verified. This provides empirical support for our departure from Dequiedt and Versaevel (2007). Relaxing the unrealistic assumption that each firm can only once contribute a patent to the pool, we predicted ongoing patent races even after pool creation. This prediction is verified by the econometric analysis. Our theoretical suggestion implies that only pool members have strong incentives to continue to introduce patents into the pool. Also this implication is confirmed by empirical evidence (Baron and Delcamp, 2010).

Our finding of a lasting positive effect of patent pools on patent declarations does not necessarily imply increased technological progress around the standard. Earlier research on the incentive effects of patent pools (Lampe and Moser, 2009) rather suggests that pools induce a higher propensity at constant innovation activity. Indeed, our empirical evidence on contemporary patent pools confirms the finding of an increase in opportunistic patent files disconnected from technological progress. By interacting pool dummies with standardization activity variables, we find that the presence of patent pools significantly reduces the link between patent declarations and standardization activity, such as amendments and version releases. We therefore suggest opportunistic patent declarations as a plausible explanation of the lasting positive effect of patent pools on the number of declarations. Baron and Delcamp

(2010) analyze patterns of patent introduction into existing patent pools. They find that pools induce their members to increase their share in the pool by introducing numerous narrow and low quality patents that are very focused on the underlying standard. We find for the first time strong evidence that these strategies have a direct incidence on the number of patents that are declared essential for the underlying standard.

CONCLUSION

With the use of a comprehensive dataset of international formal standards, we have proposed a novel and unique empirical analysis of the driving factors of patent declarations on technological standards. This framework enables us to evaluate the effects of patent pools and to confirm theoretical hypotheses on the timing of patent declarations with respect to patent pool creation. Using instrumental variables and a broad range of control variables, we isolate the contribution of patent pools to the number of patents declared essential on a standard, while ruling out size and value effects. Our analysis is yet more precise, as we establish a model of patent declarations over the lifecycle of a standard to analyze the effects of a pool launch, controlling for key events in the evolution of the standard and for shocks in the technological field.

Our results confirm Hypothesis 1 and find a positive and very significant effect of patent pools on the overall number of patent declarations. The number of patents increases holding constant the number of standard versions, amendments and pages. We therefore interpret this increase in patent declarations as adding little or no technological value to the underlying standard. This interpretation is further corroborated by the fact that the occurrence of patent pools significantly weakens the link between patent declarations and standardization activity.

We identify two main channels for the effect of patent pools on the number of patent declarations: first, as suggested by Hypothesis 2, prospective patent pool creation induces a race of declarations. Earlier research has already evidenced patterns of increased strategic patenting by prospective pool members and holders of complementary patents in view of the creation of a patent pool in the 19th Century (Lampe and Moser, 2009). We now confirm this finding for contemporary ICT patent pools based upon a comprehensive sample. Second, we corroborate Hypothesis 3 that patent pools have a lasting positive effect on the number of patent declarations even long after their creation. This finding provides evidence for the effect of royalty sharing rules inside pools on the number of patent files: as pools share royalty income according to the number of patents, pool members engage in perpetual patent races to increase or keep constant their share in the pool.

These findings will have to be borne in mind for an evaluation of the welfare effects of patent pools. Policy makers and industry participants have come to take a positive stance on patent pools, as pools play an important role in leveling the playing field for competition on the downstream production market, reducing transaction costs and encouraging the spread of innovative technology throughout the industry. In view of these benefits, patent pools are seen as indispensable instruments in cutting through the patent thickets in ICT. Indeed, by clearing blocking positions and facilitating access to the technology, patent pools help attenuating the negative downstream effects of patent thickets. On the other hand, as our analysis has pointed out, there is a risk that these positive downstream effects are offset by the fact that patent pools create incentives to exacerbate some of the worrying upstream effects of patent thickets.

Indeed, one of the harmful effects of patent thickets is to induce socially wasteful excess investment in patent races and opportunistic patent files, deviating resources away from innovation to rent seeking strategies. Even though we interpret our results as indicating opportunistic patent filing, patent activities could still result from an increase in innovation. As to our theoretic implications, we predict an overinvestment in R&D. However, we give evidence that the existence of a pool increases the number of patent declarations at given scope of standardizations processes. These numerous patents thus do not yield significant changes in the standard, but rather underline activities which are disconnected from standardization. By consequence, the holders of technologically significant patents which constitute the technological value of the standard will have to share the royalty revenue of the pool equally with the holders of a high number of patents of limited value. The obvious risk is that companies either decide to invest more in patenting and less in innovating; or that the holders of high value patents opt for standing out of new pool projects.

In order to avoid these undesirable outcomes, patent pool administrators and policy makers should make sure that the institutional setup does no longer provide incentives for the strategies that we observe. A crucial point is the definition of royalty sharing rules that take into account objective criteria of technological significance. Second, we encourage cooperation between SDOs and patent offices to guarantee a high patent quality especially for complex and highly valuable ICT standards.

REFERENCES

Baron J, Delcamp H. Strategic inputs into patent pools. Cerna working paper 2010.

Bekkers R, Duysters G, Verspagen B. Intellectual property rights, strategic technology agreements and market structure. The case of GSM. Research Policy 2002; 31; 1141–1161.

Bekkers R, Martinelli A. The interplay between standardization and technological change: A study on wireless technologies, technological trajectories, and essential patent claims. Working paper 2010.

Blind K, Gauch S. Trends in ICT standards: The relationship between European standardization bodies and standards consortia, Telecommunications Policy 2008; 32; 503–513.

Choi J P. Patent Pools and Cross-Licensing in the Shadow of Litigation. International Economic Review 2010; 51; 441–460.

Colangelo G. Avoiding the Tragedy of the Anticommons: Collective Rights Organizations, Patent Pools and the Role of Antitrust. LE Lab Working Paper 2004.

Dequiedt V, Versaevel B. Patent Pools and the Dynamic Incentives to R&D. Working paper 2007.

Delcamp H. Essential patents in pools: Is value intrinsic or induced?. Cerna working paper 2010.

Delcamp H. Are patent pools a way to help patent owners enforcing their rights?. Working paper 2011.

Gilbert R J. Anti-Trust for Patent Pools: A Century of Policy Evolution. Stanford Technology Law Review 2004; 3.

Guimarães P. The fixed effects negative binomial model revisited. Economics Letters 2008; 99; 63-66.

Iversen J E. Standardization and Intellectual Property Rights: ETSI’s controversial search for new IPR-procedures. SIIT proceedings paper 2002.

ISO, IEC, ISO/IEC. Directives Part1 2009; 7.

Koehler F, Blind K, Thumm N. Keep ’Em In, Make ’Em Fit - An Analysis of Patent Filing Behavior for Essential Patents in Standards. Working Paper 2009.

Lampe R, Moser P. Do Patent Pools Encourage Innovation? Evidence from the 19th century Sewing Machine Industry. Journal of Economic History 2009; 70; 898-920.

Layne-Farrar A. Innovative or Indefensible? An Empirical Assessment of Patenting within Standard Setting. Working paper 2008.

Layne-Farrar A, Lerner J. To Join or not to Join: Examining Patent Pool Participation and Rent Sharing Rules. International Journal of Industrial Organization 2010.

Layne-Farrar, A. Is EX ANTE the Norm? An Empirical Look at IPR Disclosure Timing within Standard Setting. Working paper 2010.

Leiponen A E. Competing Through Cooperation: The Organization of Standard Setting in Wireless Telecommunications. Management Science 2008; 54; 11; 1904–1919.

Lerner J, Tirole J. Efficient Patent Pools. American Economic Review 2004; 94; 691-711.

Rysman M, Simcoe T. Patents and the Performance of Voluntary Standard Setting Organizations. Management Science 2009; 54; 1920-1934.

Scotchmer S. Innovation and Incentives. MIT Press 2004; 34; 369 pp.

Shapiro C. Navigating the Patent Thicket: Cross Licenses, Patents Pools, and Standard Setting. In: A Jaffe, J Lerner et S, Stern (Eds), Innovation Policy and the Economy, vol. 1. MIT Press 2001.

Simcoe T. Explaining the Increase in Intellectual Property Disclosure. In: Sheri Bolin (Eds), The Standards Edge: Golden Mean. Ann Arbor: Bolin Communications 2006.

Appendix 1: Number of standards with at least one patent statement / mean declarations per standard by SDO and ICS class (including ETSI on project level)

SDO	Standards including patents (sample share)		Median	Mean
JTC1	108	(14.36%)	3	16.81
IEC	68	(9.04%)	1	1.74
ISO	90	(11.97%)	1	2.67
IEEE	73	(9.71%)	2	26.97
ITU-T	291	(38.70%)	2	7.09
ITU-R	20	(2.66%)	8	31.55
CEN-CENELEC	17	(2.26%)	1	1
	TS	/ Project	per TS / Project	per TS / Project
ETSI	732 / 85 (11.30% project share)		7 / 14	64,85 / 704.63

ICS	Number of Standards (sample share)		Median	Mean, declarations per standard
03: Services	4	(0.55%)	4.5	4.25
25: Manufacturing Engineering	28	(3.84%)	1	1.82
29: Electrical Engineering	5	(0.68%)	1	1.2
31: Electronics	12	(1.64%)	1	1.67
33: Telecommunications.	393	(53.84%)	2	156.44
35: Information Technology.	256	(35.07%)	2	14.27
37: Image Technology	7	(0.97%)	3	8.14
43: Road Vehicle Engineering	7	(0.96%)	1	1.57
49: Aircraft / Space Vehicle	9	(1.23%)	1	1.11
97: Household / Commercial Equipment.	9	(1.23%)	1	1

Appendix 2: instrumented OLS regression (with instrument variable test: underidentification test and Sargan statistics):

	SDO sample (excluding ETSI)	**ETSI sample** (only ETSI)

	instrumented OLS Coefficient (Z statistic)	**instrumented OLS** Coefficient (Z statistic)
patent pool exists (instrumented)	5.00393*** (8.49)	14.22916*** (3.10)
consortium exists	-.2009232 (-1.04)	1.542752 (0.71)
number of standard releases	-.0240644 (-0.42)	.0717813 (1.41)
number of standard amendments	.0430025*** (3.27)	/
standard age	.0026941** (2.55)	-.0204521 (-1.31)
standard age squared	-1.09e-06 (-0.75)	.000025 (1.05)
Observations	580	608
R-squared	0.0657	
underidentification test (F):	34.728	10.92
Sargan statistics (p):	0.0851	0.0805

instrumented: patent pool exists

instruments: co-disclosure, pool experience, pools per SDO (only for SDO sample)

* represents the level of significance: * = 10%-level; ** = 5%-level; *** = 1%-level

note: control dummies for SDOs, technological standard classes (ICS) and standard document types are not displayed in the results

Appendix 3: cross section negative binominal without instruments

	SDO sample (excluding ETSI)	**ETSI sample** (only ETSI)
	negative binominal Coefficient (Z statistic)	**negative binominal** Coefficient (Z statistic)
patent pool exists (without instruments)	1.214184*** (4.82)	.5677409** (2.16)
consortium exists	.3393825* (1.92)	-.0204805 (-0.05)
number of standard releases	-.1880117* (-1.83)	.0544649 (0.98)
number of standard amendments	.1443677 *** (7.27)	/
standard age	.0169143 (0.91)	.1678942*** (3.73)
standard age squared	-.0000112 (-0.74)	-.0001518*** (-4.03)
Observations	508	618
R-squared	0.2009	0.0597

* represents the level of significance: * = 10%-level; ** = 5%-level; *** = 1%-level

note: control dummies for SDOs, technological standard classes (ICS) and standard document types are not displayed in the results

Appendix 4: fixed effect poisson panel estimator

	SDO sample (excluding ETSI)	ETSI sample (only ETSI)
	fixed effects poisson coefficient (Z statistic)	**fixed effects poisson** coefficient (Z statistic)
3-4 periods before pool launch	.6399324*** (6.62)	-.7565082*** (-7.86)
1-2 periods before pool launch	.8250743*** (10.09)	.2017728*** (6.52)
1-2 periods after pool launch	.9677636*** (13.45)	1.472193*** (19.56)
3-4 periods after pool launch	.3593967*** (4.66)	1.088945*** (5.12)
informal standards consortia exists	.3516322*** (16.95)	-.7084191*** (-2.68)
number of standard pages this period	.0001194*** (4.18)	-.0028623*** (-12.58)
periods around standard release	.5160614*** (15.37)	/
period of standard amendment	.0058855 (-1.51)	/
standard age	.1524759*** (26.47)	.2816562*** (26.80)
standard age square	-.0001437*** (-26.25)	-.0002448*** (-25.47)
patent filing intensity	9.81e-13*** (10.21)	-4.26e-12*** (-18.32)
lag patent filing intensity	9.01e-13*** (8.60)	-5.01e-12*** (-29.48)
total declarations this period	.0026664*** (29.56)	.00021*** (83.17)
observations	7565	5977
groups	445	397
log pseudolikelihood	-6238.5148	-24290.093
AIC	12788.11	48598.19
BIC	12871.29	48658.45

* represents the level of significance: * = 10%-level; ** = 5%-level; *** = 1%-level

ACKNOWLEDGEMENTS

We are grateful to Knut Blind, Yann Ménière and Henry Delcamp for active support during our research. We further thank Tim Simcoe, all participants from the INTERTIC Conference in Milan and in particular Federico Etro and all participants from the ICT Growth Conference in Munich and in particular Shane Greenstein and Rob Seamans for their comments and suggestions.